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Mariners Weather Log

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U.S. DEPARTMENT OF COMMERCE
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ENVIRONMENTAL DATA SERVICE
Thomas S. Austin, Director

Cover: The AFRICAN SUN appears to be floating on a cloud off Duluth on December 2, 1975. The cloud is steam fog rising from the comparatively warm water of the lake (5°C). The air temperature was near -17°C. For a discussion of winter navigation and ice on the Great Lakes during the 1975-76 season, see article on page 328. Wide World Photo.

The Secretary of Commerce has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical approved by the Director of the Office of Management and Budget through June 30, 1980.

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Mariners Weather Log

Editor: Elwyn E. Wilson
Editorial Assistant: Annette Farrall

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Volume 20 Number 6
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Mariners Weather Log

A BRIEF HISTORY OF U.S. COAST GUARD ICEBREAKERS

Richard Meidt and Daniel Mills
United States Coast Guard
Seattle, Wash.

Historically, the Coast Guard's need for an icebreaker arose out of the purchase of Alaska by the United States from the Imperial Russian Government in 1867. In fact, the U.S. Revenue Cutter Service's (as the Coast Guard was then known) cutter LINCOLN had been dispatched north that same year to make the first official exploration of the new territory. Out of this voyage was born the Service's Bering Sea Patrol and other Alaskan activities, some of which are still carried on to the present day.

At this time both whaling and sealing were enjoying a boom period in the polar regions. And, through bitter experience, a strengthened version of the ordinary wooden sailing ship, with the addition of auxiliary steam engines and a feathering or hoisting screw, had been developed and proved quite successful. These ships had heavier bow framing, and the hull planking was sheathed with ironbark or greenheart along the waterline to withstand the scoring action of ice. The stem was also plated with iron, but in most other respects their design and construction followed the general shipbuilding practice of the period.

A notable example of this type was the renowned auxiliary barkentine BEAR (figs. 1 and 2), the first Coast Guard-acquired vessel specially strengthened for work in Arctic ice. Other early ones were THETIS and CORWIN, but the BEAR was destined to have the longest association with the Service.

Built at Dundee, Scotland, in 1874 as a whaler and sealer, the BEAR had an overall length of 198 ft, a maximum draft of 18 ft, 1,700 tons displacement, 350 shaft hp, and a reciprocating steam engine in her main propulsion plant. The U.S. Navy had originally purchased this ship as a relief vessel in connection with

Figure 1.--The BEAR played a prominent role in the opening of the Alaskan territory. U.S. Coast Guard Photo.

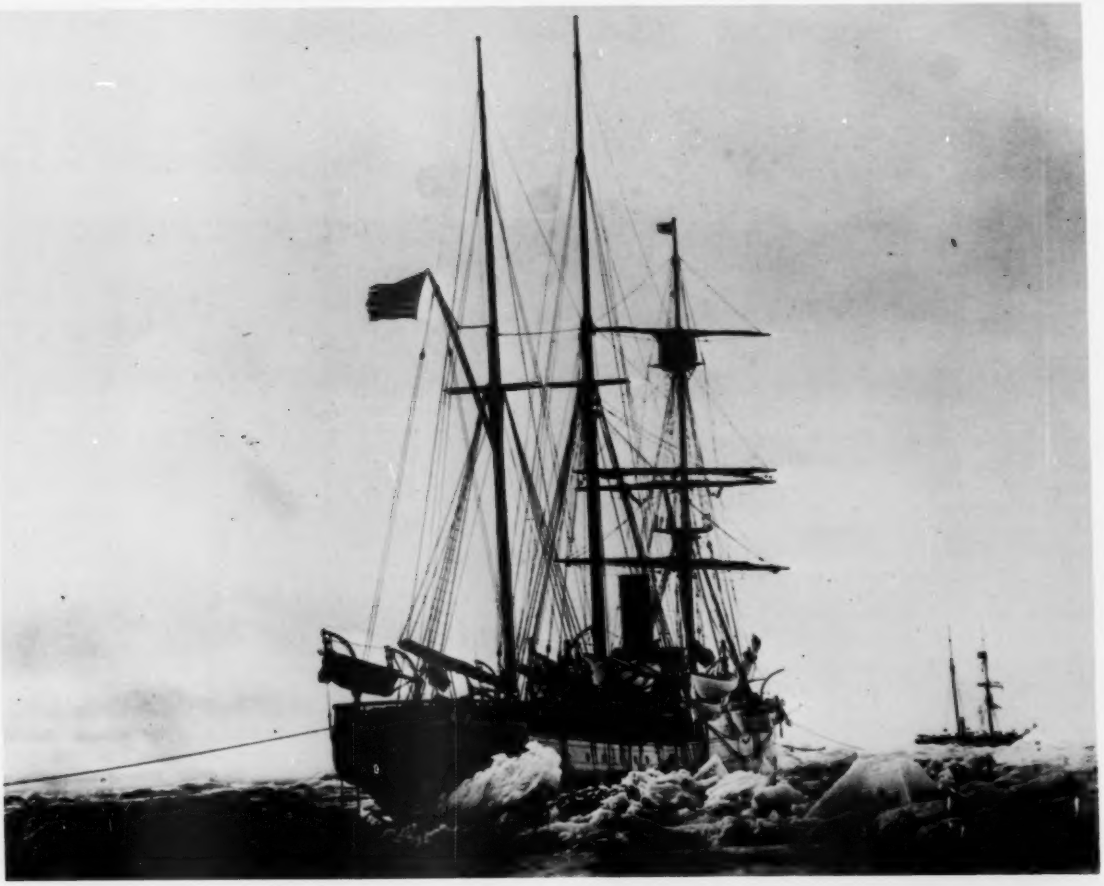

Figure 2.--Here at the prime of her colorful career the BEAR, in jammed ice off the northern coast of Alaska, attempts to reach the trapped cutter CORWIN. U.S. Coast Guard Photo.

the ill-fated Greeley Expedition. In 1885, after successfully completing several Arctic missions for the Navy, the BEAR was transferred to the U.S. Revenue Cutter Service for patrolling Alaskan territorial waters. From 1885 to 1926, when she was assigned elsewhere, she operated in Alaskan waters (fig. 3). To replace her in these waters, the Coast Guard built the NORTHLAND in 1927.

Since the BEAR had proven so satisfactory in performing the routine Coast Guard duties during her many years of service in Arctic waters, many of her characteristics were incorporated into the NORTHLAND. Built by the Newport News Shipbuilding Company in Virginia, this new vessel had an overall length of 216 ft, maximum draft of 15 ft, 2,050 tons displacement, 1,000 shaft hp, and a main propulsion of two diesel engines. Although the massive wooden hull of the old BEAR had been replaced with steel in the NORTHLAND, she was still rigged as a barkentine ship to satisfy the old line, experienced Arctic skipper, who hesitated to take a ship into Arctic ice without sails as an auxiliary means of propulsion.

One of the new features incorporated into the NORTHLAND was a cutaway bow, typical of European vessels which had proved successful in Arctic operations by other nations. Although NORTHLAND was able to break light ice, she was not built primarily as an icebreaker; instead, she was built with sufficient strength to withstand the contacts with ice accompanying navigation in fields of broken ice, with sufficient endurance to permit operating away from a base for long periods of time, and to give the crew a reasonably good chance of surviving until the thaw should the vessel become entrapped.

All things considered, the NORTHLAND proved to be a worthy successor to the BEAR. The Coast Guard used her in Arctic operations through World War II (fig. 4). She was decommissioned in 1946.

For some time the Coast Guard's extensive experience in the Arctic had pointed up the desirability of having vessels designed not only for operating in ice, but also capable of breaking ice. Moreover, the Service's mission of assistance to vessels in distress also indicated a need for icebreakers. A vessel beset by ice is in some form of distress, and Coast Guard cutters traditionally go to their assistance. All of this experience and background, nevertheless, had little effect upon the design of Coast Guard ships until

Figure 3.--Hauling supplies from the BEAR to stranded whalers. The artist was Horatio N. Wood, First Assistant Engineer aboard the BEAR during the relief expedition of 1897-98. U.S. Coast Guard Photo.

Figure 4.--The NORTHLAND during World War II rescued downed fliers on the Greenland Ice Cap. U.S. Coast Guard Photo.

the 1930's.

Prior to this time, there had been little serious attention paid within the United States to icebreaking or even the need for it. The reason for this neglect was probably twofold: (1) All U.S. tidewater ports are relatively ice free, and (2) the development of U.S. transportation came about without relying upon icebreaking--coastwise traffic did not need it, and inland regions were served by rail. Unlike northern Europe, the United States had not had to depend upon canals and inland waterways to any great extent.

During the 1930's an additional icebreaking requirement developed with the coming of the oil barge and the expedient of using waterways, especially in New England, for fuel deliveries. This ultimately led to President Roosevelt's issuing Executive Order No. 7521, dated December 21, 1936, that directed the Coast Guard "to assist in keeping open to navigation by means of icebreaking operations... channels and harbors within the reasonable demands of commerce." Even with this new authority, however, no requirement was spelled out for either the United States or the Coast Guard to secure a vessel specifically designed as an icebreaker. And, it would take the advent of World War II to bring about the acquisition of such vessels.

Subsequent to the launching of the NORTHLAND, the Coast Guard built several other vessels with ice-operating features, such as the six cutters of the ESCANABA class built from 1931-35. Much was learned from the ice operation of these vessels in regard to the desirability of various types of propulsion machinery, the design precautions necessary to insure proper operation of the machinery in ice, and the structural effects of ice operations upon the hull.

In 1937 the Coast Guard instituted a study of the entire problem of icebreaking, including a review of all the data obtainable on the characteristics and performances of all icebreakers ever built. It even dispatched a representative to Europe to inspect and gather information on the icebreakers built for Russia, Sweden, Denmark, and Holland. In addition, investigations were conducted to find the most effective hull form for breaking ice, as well as developing the proper relation between displacement, hull strength, and horsepower. The results of this study were incorporated into the design of a group of 110-ft harbor tugs (fig. 5).

The first Coast Guard cutters designed primarily with icebreaking characteristics, therefore, were the RARITAN and NAUGATUCK, which were completed in April 1939. They were single-screw, diesel-electric vessels of 110 ft overall length, 10-1/2 ft draft, 328 tons displacement, and 1,000 shaft hp. Once placed into service, they proved very successful, even breaking sheet ice 20 in thick without resorting to charging and ramming. During World War II they worked under very severe ice conditions without suffering hull damage. Because of their eminently successful performance as icebreakers, many of the characteristics of these vessels were included in the group of 180-ft buoy tenders next to be built and known as the CACTUS class (fig. 6).

The next icebreaking vessel to be designed by the Coast Guard was the CACTUS, a single-screw, diesel-electric buoy tender of 180 ft overall length, 12-ft maximum draft, 935 tons displacement, and 1,000

Figure 5.--The harbor tug SAUK breaking ice in the Hudson River. U.S. Coast Guard Photo.

Figure 6.--The tender BRAMBLE on its historic Northwest Passage run in 1957. This vessel with the SPAR and STORIS made the first successful deep-draft transit of Bellot Strait from west to east. U.S. Coast Guard Photo.

shaft hp. Built in 1941, this cutter had approximately the same hull form and general structural arrangement as that incorporated so successfully in the harbor tugs.

By this time, during the hectic uncertain days just prior to World War II, naval operations in the vicinity of Greenland had revealed a need for an icebreaker to cope with the ice conditions existing offshore and in

Figure 7.--The WIND class icebreaker EASTWIND climbs onto solid ice 15 to 20 ft thick in McMurdo Sound. Backing off and slamming forward again repeatedly, she cuts a channel through the ice. U.S. Coast Guard Photo.

the fjords. Based on the general duty requirements known at that time, construction of the cutter STORIS, which was somewhat larger than the CACTUS class but of the same general type, was commenced in 1941 for operating in the subpolar regions of Greenland and Labrador. The general dimensions of the STORIS were an overall length of 230 ft, 15-ft maximum draft, 1,715 tons displacement, 1,800 shaft hp, and diesel-electric, single-screw main propulsion.

The culmination of this series of vessels was four heavy-duty, oceangoing icebreakers of the NORTHWIND or WIND class (fig. 7), so called because it was planned to name them NORTHWIND, EASTWIND, SOUTHWIND, and WESTWIND. These vessels were unique, being the first of their kind to be specially constructed to withstand the terrific pressure of polar ice and to deal shattering blows to it. They were born as a result of World War II emergencies.

When the Nazi invasion of Denmark in May 1940 made it advisable for the United States to assume Denmark's burden of defending Greenland, two Coast Guard cutters were ordered to proceed there immediately. Soon other vessels were attached to the Greenland Patrol Force, increasing its effectiveness. As Greenland operations were extended, it was discovered that proposed U.S. Army and Navy bases were located at sites that could be reached in certain seasons only with the help of a most able type of icebreaker.

Design on the type of polar icebreaker that would be needed started immediately. Fortunately, the many years of studying, planning, and improving on the designs of the older European types of oceangoing icebreakers by Coast Guard engineers now paid off. Initial appropriation for the WIND class of four of the heaviest icebreakers yet to be constructed was received on October 28, 1941.

For more icebreaking ability, the design called for greater displacement and horsepower, maneuverability, restricted length, and efficient steering gear; because of the remoteness of the field of operation, reliability and economy of fuel were important considerations. Because of her outstandingly successful record, the Swedish icebreaker YMER was selected as a prototype for the WIND class. The characteris-

tics adopted were 269 ft length, 63-1/2 ft beam, 25-3/4 ft draft, 5,300 tons displacement, 10,000 shaft hp on three propellers, one forward and two aft.

Meanwhile, as part of the defense effort, the Coast Guard had chartered several Great Lakes car ferries for systematic icebreaking operations on the lakes. One of the big problems throughout World War II, but particularly in the early stages, was the need to deliver iron ore in sufficient quantities to meet the demand for increased steel production. One of the steps taken was the prolonging of the navigation season of ore carriers on the Great Lakes by freeing the channels of congested ice. An outgrowth of this effort was the construction of the MACKINAW (fig. 8).

On December 17, 1941, just 10 days after the attack on Pearl Harbor, her construction was authorized. Nothing in her basic design was to detract from her icebreaking capabilities; she was to be a true icebreaker in all respects. The dimensions and characteristics were 290 ft overall length, 74-1/3 ft beam, 19-ft draft, 5,000 tons displacement, with 10,000 hp driving three propellers.

She was built at Toledo, Ohio, being launched sideways on March 4, 1944, and commissioned in the service of the Coast Guard on December 20, 1944. The icebreaker arrived at Cheboygan, Mich., on December 31, 1944, and has remained homeported ever since. At the time of the MACKINAW's launching, she was then the most powerful, most modern, and most capable icebreaker in the world for her designed purposes.

As the WIND class icebreakers were being built, the United States was a participant in World War II. Since the Coast Guard had been transferred to the Navy, these vessels were constructed under the joint auspices of the Navy and the Coast Guard, although their operation remained primarily with the Coast Guard. The design agent for the WIND class was the same as for the MACKINAW.

Before the first one was ever launched, however, the Soviet Union requested that the four polar icebreakers be transferred to its custody. Since the military situation had changed by the time the ships were being finished (1944), all but the EASTWIND were transferred to the Russians.

The first, NORTHWIND, was delivered to the So-

Figure 8.--The MACKINAW or "Big Mac," as she is affectionately called on the Great Lakes, escorts a carrier through heavy ice near the Soo Locks. U.S. Coast Guard Photo.

viet Union under the Lend-Lease Program in 1944. They renamed the ship SEVERNY VETER, which is Russian for NORTHWIND, and assigned her to the Northern Sea Route Command, where she served until her ultimate return to the United States in 1951. The following year she was renamed USS STATEN ISLAND and became part of the Navy's icebreaker fleet.

The Coast Guard icebreaker SOUTHWIND was commissioned on July 15, 1944. After serving on the Greenland Patrol from October 6 to November 18, 1944, during which time she took part in the capture of the German weather observation trawler EXTERNSTEINE (October 16), the SOUTHWIND was transferred to the U.S.S.R. on March 20, 1945. The Russians renamed her the ADMIRAL MAKAROV after the famous Russian mariner and naval architect who designed and built the world's first oceangoing icebreaker, the YERMAK, in 1898. For the next 4-1/2 yr, the ADMIRAL MAKAROV operated as a unit of the Russian Merchant Marine along the Northern Sea Route north of Russia and Siberia. In 1950 Russia returned this lend-lease ship. After 2 mo repair, the vessel was commissioned in the U.S. Navy as the USS ATKA and became part of the Navy's icebreaker fleet.

The Coast Guard icebreaker WESTWIND was commissioned on September 18, 1944. On Thanksgiving Day of the same year, orders were received aboard her that she was to be loaned to the U.S.S.R. In a matter of months, Russian, instead of English, was spoken on her decks and her new name was SEVERNY POLUS. In 1952 Russia returned the icebreaker to the United States and the Coast Guard. The cost of reconditioning her, once again named the WESTWIND, after hard Russian usage, was $1.2 million.

The Coast Guard icebreaker EASTWIND was commissioned on June 3, 1944. After a shakedown cruise in July, she reached her homeport of Boston, Mass., the following month. Her first mission during World War II was as part of the Greenland Patrol. Upon reaching northeast Greenland, she fought 10-ft ice to rescue two men in a small boat that had gotten lost from an Allied patrol. Pushing still farther northward, the EASTWIND sighted a German weather station in October 1944. During the next 15 days, landing parties from the EASTWIND captured the station, its valuable documents, and a German expeditionary vessel. The rest of the war was spent working in the thick polar ice and ferreting out various enemy infiltrations (fig. 9).

When World War II ended, the United States possessed one seagoing, deep-draft icebreaker, manned and operated by the Coast Guard. This vessel, the EASTWIND, remained a part of the Coast Guard's fleet when the Service reverted from the Navy back to the Treasury Department in 1946.

During the war, money had been allocated for three replacement icebreakers of the WIND class to take the place of those loaned to Russia. These vessels were not completed, however, until 1946 and 1947. At that time, the Coast Guard was being cut back from a wartime strength of about 144,000 to approximately 17,000 officers and men. Unable to man three icebreakers, the Coast Guard accepted one of the new icebreakers as the new or second NORTHWIND (fig. 10), and the remaining two were commissioned in the U.S. Navy as the BURTON ISLAND (fig. 11) and EDISTO.

While the Navy had operated in the polar regions for many years, this action marked the beginning of the Navy's icebreaker fleet. Within a decade, in 1954, the Navy built another icebreaker, the USS GLACIER. Although the design of this new 5,100-ton icebreaker followed that of the WIND class, the GLACIER was improved and enlarged to increase its capability.

Thus, the postwar period found the United States with eight seagoing icebreakers--five operated by the Navy and three by the Coast Guard. The remaining U.S. icebreaking capability, which was essentially domestic in nature, was represented by the MACKINAW on the Great Lakes, the STORIS primarily for subpolar Alaskan duty, the buoy tenders, and the 110-ft harbor tugs that had icebreaking features incorporated into their designs.

By 1960 Congress had passed bills authorizing the

Figure 9.--A closeup of the EASTWIND's reinforced bow riding up over Antarctic ice 7 to 15 ft thick. U.S. Coast Guard Photo.

Figure 10.--The NORTHWIND transiting the Northwest Passage in 1969 to meet the tanker MANHATTAN on its historic voyage to Prudhoe Bay. U.S. Coast Guard Photo.

Figure 11.--As ice begins to close the passage to the North Slope of Alaska, the BURTON ISLAND (WAGB 283) relieves the disabled icebreaker GLACIER from the Prudhoe Bay Resupply Mission of 1975. U.S. Coast Guard Photo.

Figure 12.--The WESTWIND on an Arctic resupply mission. During the last two winters the icebreaker saw service on the Great Lakes. U.S. Coast Guard Photo.

Figure 13.--The POLAR STAR, the newest Coast Guard icebreaker, has little trouble on her first voyage through ice off Alaska waters. U.S. Coast Guard Photo.

construction of a nuclear-powered icebreaker for operation by the Coast Guard. The Soviet Union had pioneered this by constructing the nuclear-powered icebreaker LENIN, which was far larger and more powerful than any the United States possessed. Presidential opposition, based primarily upon the prohibitive cost of an atomic icebreaker, doomed these pieces of legislation.

Within 5 yr, however, the Coast Guard's icebreaker fleet was to undergo a tremendous increase. The Navy and the Coast Guard had made an exhaustive study of their joint operation of icebreakers in polar regions. The study showed that consolidation of the icebreaking function in the Coast Guard would be in the best national interest. Organizationally, this transfer of the Navy's icebreakers to the Coast Guard in 1965 made a lot of sense. It concentrated the Federal icebreaking function in an agency that was qualified both historically and legislatively to carry out the responsibility.

Undoubtedly, the increasingly tense international situation--heated up by the Vietnam conflict--played an important part in this transfer. The Navy found itself deploying fleet units to an ever-growing number of crisis areas. With the transfer of the polar icebreaking function to the Coast Guard, the Navy would be in a position to free larger numbers of personnel for combat tasks. In short, this transfer amounted to a realinement of logistic plans to meet the realities of the troubled world situation.

Under the agreement between the Treasury and Navy Departments, the Navy's icebreaker fleet--the USS EDISTO, USS ATKA, and the USS BURTON ISLAND--was transferred individually to the Coast Guard. The Coast Guard retained the names of these icebreakers, except for the ATKA, which resumed its former Coast Guard name of SOUTHWIND.

Since the decommissioning of the EASTWIND in 1968, the icebreakers SOUTHWIND, STATEN ISLAND, and EDISTO have been decommissioned, leaving the BURTON ISLAND, GLACIER, NORTHWIND, WESTWIND (fig. 12), and MACKINAW as the only active Coast Guard icebreakers.

The latest Coast Guard icebreaker, POLAR STAR, was commissioned in January 1976. (See Mariners Weather Log, 20 (5), p. 263, July 1976.) She completed her first ice tests (fig. 13) in the Arctic off Alaska in May and June.

HIGH WINDS OVER THE CARIBBEAN SEA

Ronald R. White
National Weather Service, NOAA
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During the morning of July 8, 1976, a telephone call was received at the Weather Service Forecast Office in Miami through the high-seas radio telephone operator. A boat about 100 mi south of Jamaica, although in relatively clear weather, was experiencing 40-kn winds and 25-ft seas. Those aboard the boat feared that they had unknowingly wandered into the fringe of a hurricane or tropical storm. During the next 36 hr, several ships reported winds from 30 to 40 kn and wave heights from 15 to 25 ft.

For mariners who frequent this area of the Caribbean (generally between 12° and 17°N and 70° to 80°W) this is not an uncommon occurrence. During July and January (figs. 14 to 17[1]), the mean windspeeds are between 20 and 25 kn, and a deviation of 10 kn upward from the normal will produce near gale-force winds. Climatological records indicate that two peaks occur annually over this area--one during the winter from mid-December through March, and the other from mid-June through July.

[1] Derived from U.S. Navy Marine Climatic Atlas of the World, Volume I, North Atlantic Ocean (Revised 1974).

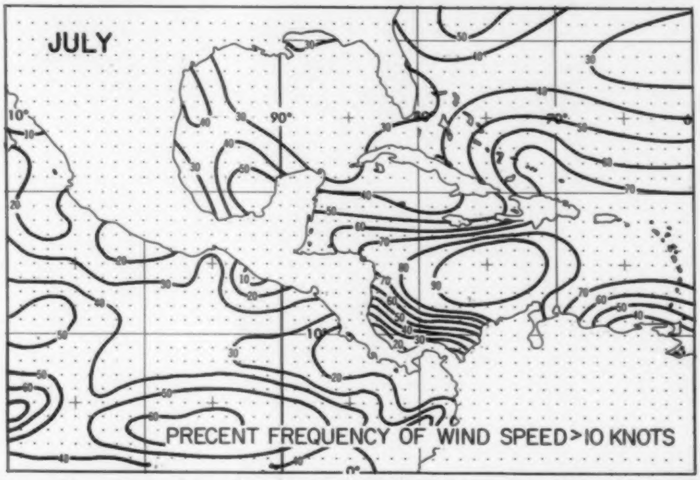

Figure 14.--Percentage frequency of windspeeds greater than 10 kn, July.

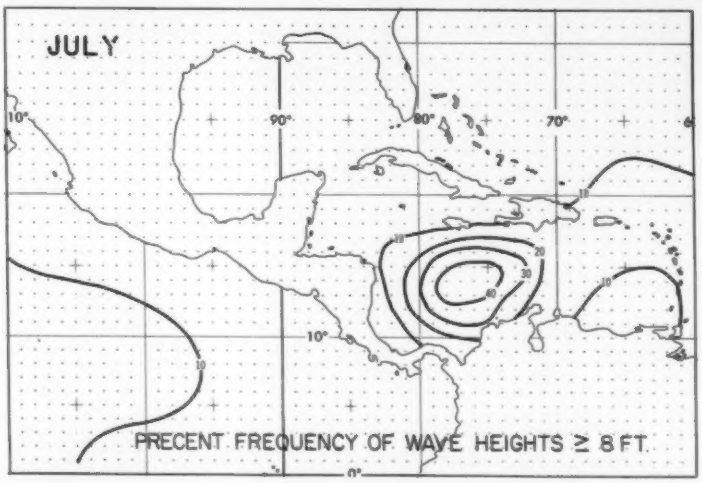

Figure 15.--Percentage frequency of wave heights equal to or greater than 8 ft, July.

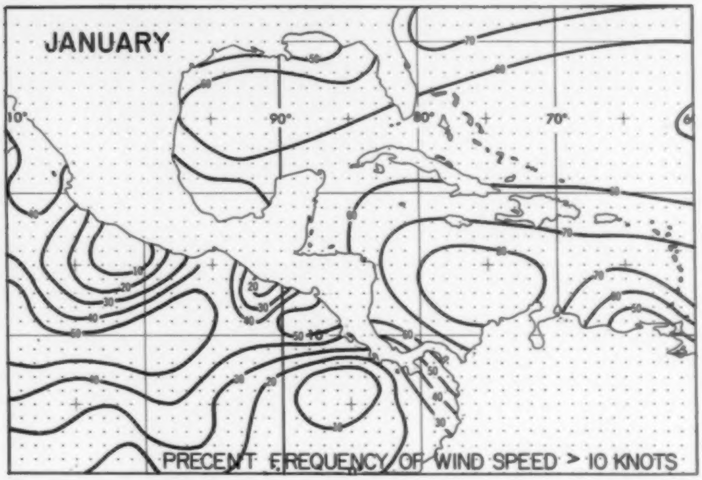

Figure 16.--Percentage frequency of windspeeds greater than 10 kn, January.

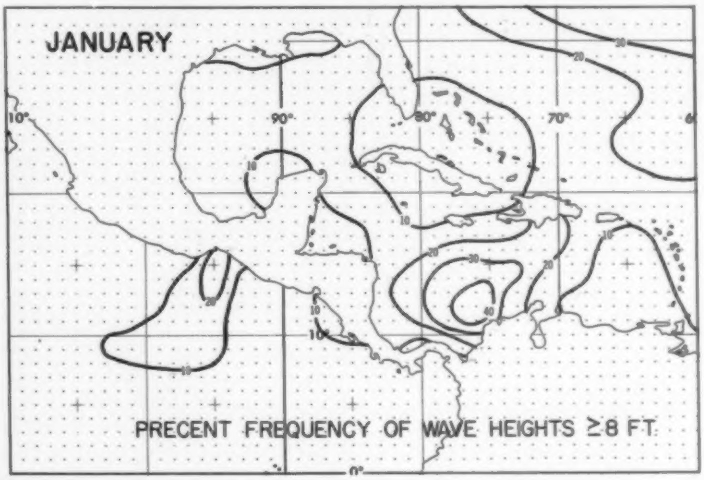

Figure 17.--Percentage frequency of wave heights equal to or greater than 8 ft, January.

The reasons for a concentration of higher winds in this region are not fully understood, but they are thought to be related to a lee trough which sets up over the Isthmus of Panama. This trough results from the effect of easterly winds blowing against a ridge of high mountains over northern South America.

During June and July it is thought that the high winds are related to surges (abrupt wind increases) which move westward across the tropical Atlantic with a weekly periodicity. It has also been suggested that the movement of the equatorial trough to a position near the Isthmus during this time coupled with periodic pressure rises in the Atlantic causes an increased pressure gradient and strengthening of winds. The duration of these surges generally ranges from 36 to 72 hr. During the winter there is a southward drift of the Atlantic high-pressure ridge resulting in a tighter pressure gradient and higher winds over the entire Caribbean. These stronger winds again are accentuated over the area northeast of the Isthmus of Panama so that winds of 30 kn or more are not at all uncommon.

In any event, when the meteorologist notes a pressure difference of 7 mb or more between Jamaica and Panama, he should expect winds of 30 kn or greater along with associated high seas.

The mariner who transits this area during June and July and during the winter, even under almost cloudless skies, should be prepared to occasionally experience gale-force winds and heavy seas.

This phenomenon has not been given the attention as some others, such as the "northers" in the Gulf of Mexico or the "Tehuantepecers" in the Gulf of Tehuantepec.

Mariners who encounter unusually high winds in this portion of the Caribbean are invited to correspond with the author at the Forecast Office, NWS/NOAA, c/o University of Miami Computing Center, 1365 Memorial Drive, Coral Gables, FL 33124.

Mariners Weather Log

TIDAL FLUCTUATIONS IN NEW YORK HARBOR DURING AN INTENSE STORM [1]

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National Weather Service, NOAA
New York, N.Y.

It is important that forecasters be aware of unusual characteristics of storm surges that accompany intense coastal storms. This article describes an unusual event for New York Harbor (fig. 18).

Tides in the Upper Bay of New York Harbor, measured at a location called "The Battery," are usually higher than the astronomical tide while a strong low-pressure system is moving northward along the coast toward New York City. Winds from an offshore, or easterly, direction prevail in New York while the storm's center is to the south. When the center of the Low moves north of New York, the winds shift to an offshore direction (west to northwest) and the tide begins to fall, soon reaching levels below the astronomical tide. It was not surprising, then, that during an explosively deepening, intense winter storm on February 2, 1976 (figs. 19 and 20), tides at The Battery fell from more than 2 ft above predicted astronomical levels at 0900, when the northward-moving storm's center was over Long Island, to more than 4 ft below astronomical tides at 1530 (fig. 21) (Mariners Weather Log, 20 (4), p. 225, July 1976). At 1530, however, there was a sudden reversal, and for 2 hr the water level rose. Thereafter, the water level fell again, reaching one of the lowest values recorded in years, and causing some problems for shipping. What caused the water level to rise between 1530 and 1730 when strong offshore winds were blowing with gusts in excess of 45 kn and the astronomical tide was falling?

Tidal records for New York Harbor show that tidal resurgence after northward passage of an extremely intense storm center has occurred in the past. It

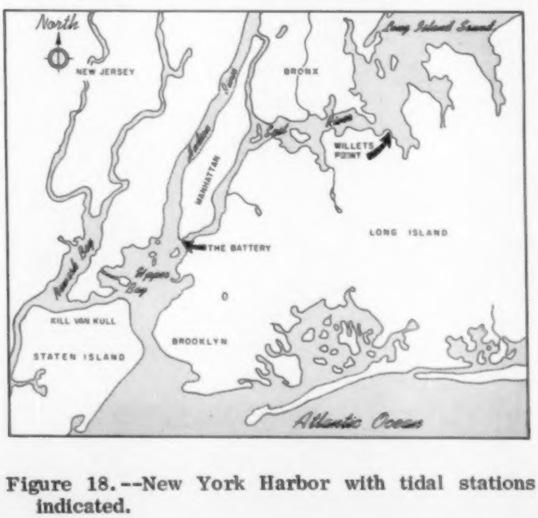

Figure 18.--New York Harbor with tidal stations indicated.

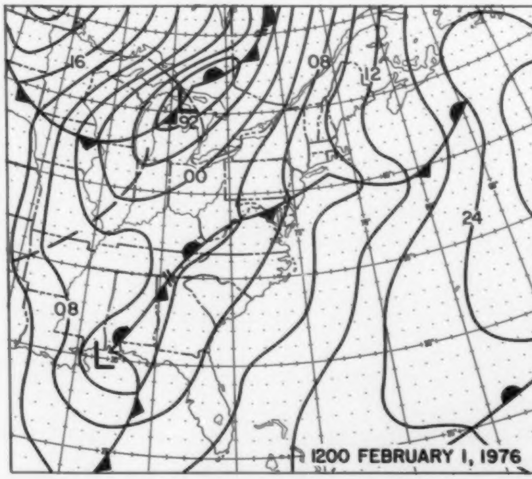

Figure 19.--Surface weather map for 1200, February 1, 1976.

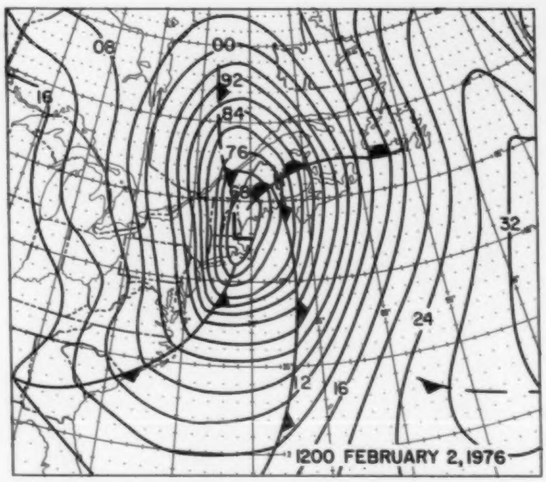

Figure 20.--Surface weather map for 1200, February 2, 1976.

[1] Published by National Weather Service Eastern Region Headquarters, Garden City, N.Y., as "Eastern Region Technical Attachment No. 76-13A, June 7, 1976.

happened during the hurricanes of September 21-22, 1938, September 13-15, 1944, and hurricane Carol on August 30-31, 1954. The surface pressure system with the storm of February 2, 1976, very much resembled that of a hurricane. Harris (1963) explained that, "There are two paths for any tide entering New York City: one from the south through New York Bay and the other from the east through Long Island Sound. . . . the surge traveling through the Sound may arrive in the western end of the Sound after all other aspects of the storm have abated; for the travel time through the Sound is much longer than that from the south.

For the storm of February 1-2, 1976, a tide gage record for Willets Point at the western end of Long Island Sound showed the water level there had been 3 to 4 ft higher than the astronomical tide from the afternoon of February 1 until after 1200 on February 2. There was no further rise at Willets Point after the storm's center passed on the early morning of the 2d. The Willets Point tide remained above the astronomical tide until 1630, 4 hr later than at The Battery, and then began to fall sharply. Tide information at Willets Point was missing after 1200, when it was 3-1/2 ft above the predicted astronomical level, until 1500 when it was 1 ft above this level. It is assumed the tide remained above astronomical levels during this missing data period. Between 1500 and 1700 (noon) the water level at Willets Point was more than 4-1/2 ft higher than at The Battery. By 1800 the difference was only 1 ft. Evidently, a contributing cause to the increase in tides at The Battery between 1530 and 1730, when forecasters were expecting a continuation of the sharply decreasing water level, was the storm surge still traveling the long route to New York Harbor, first westward through Long Island Sound and then southward down the East River, which connects the Sound with the Upper Bay of New York Harbor. In this case, this may not be the only explanation. As the Low's center passed north of New York at 0900, the winds became northwesterly and remained strong from this direction until 1500. A northwesterly wind direction closely parallels the orientation of the exit from the Upper Bay of New York Harbor into the ocean (fig. 18) and is highly efficient in driving water out of the Upper Bay. At 1500 the wind direction turned more westerly. This slowed the flow of water out of the Upper Bay to the extent that less was now leaving than coming in, as the last of the surge came down the East River. After the surge of water from Long Island Sound ended at 1730, the water levels resumed their decline at The Battery. Another source of water entering the Upper Bay of New York Harbor between 1530 and 1730 is Newark Bay to the west. Earlier northwesterly winds would pile the water in this Bay at its southern end; westerly winds would then accelerate the flow of this piled up water through Kill Van Kull, a west-to-east oriented channel, into the Upper Bay. A third and final source of water entering New York Harbor is the Hudson River. The contribution of flow from this river to the tidal resurgence, in this case, is not thought to be significant.

From the above, it can be seen how complicated storm tide predictions can be and why it is important for forecasters to be knowledgeable of local effects on the tides, just as they must be knowledgeable of local effects on the weather.

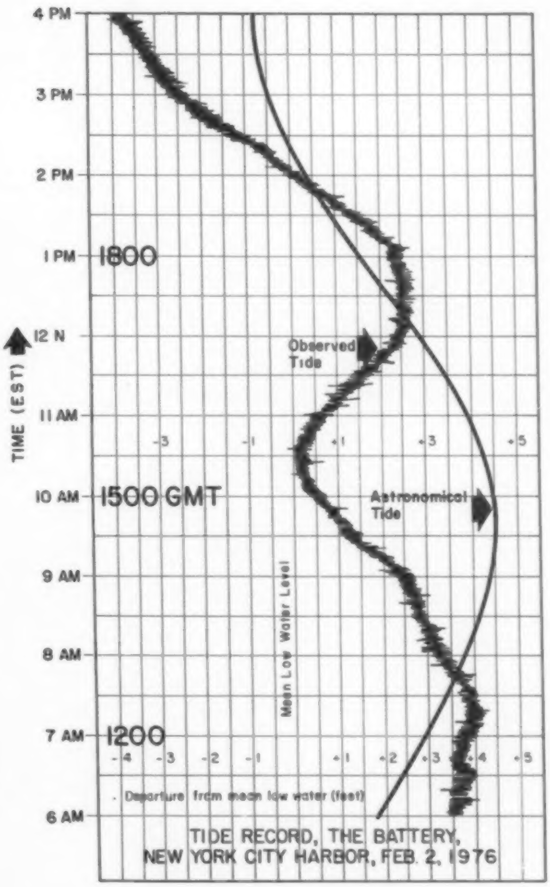

Figure 21.--Tidal record at The Battery for February 2, 1976.

REFERENCE

Harris, D. L., 1963, "Characteristics of the Hurricane Storm Surge," U.S. Weather Bureau Technical Paper No. 48.

GREAT LAKES ICE SEASON, 1975-76

YEAR-ROUND NAVIGATION CONTINUED

Daron Boyce
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Great Lakes navigation continued without a break for the second season in a row during the winter of 1975-76. Strong contrasts in the weather from month to month during the season resulted in significant relief in ice conditions making continued transits possible. Navigation has not stopped since April 2, 1974. Without the assistance of many governmental agencies under the Great Lakes Extended Season Demonstration Program, this would not have been possible.

FALL SEASON

Encouraged by forecasts of generally late ice formation, 10 shipping companies made plans during early fall to participate in the extended season (any shipping beyond December 15). Air temperatures from May through October averaged above normal in most areas, and the lake heat storage was above normal. A cold September followed by a warm October moderated the summer's effects, but a very mild early November balanced the totals again.

Temperatures during early November set high records in many Great Lakes ports. Some stations experienced the warmest November in 100 yr. As usual, the storms of November made their visits to the Lakes. On the 9th, a storm center developed over Colorado and moved into the Lakes on the 10th with a central pressure of 984 mb. The deep storm was relatively small in area and passed through eastern Lake Superior. Winds in excess of 75 kn and waves of 30 ft were reported by the ARTHUR ANDERSON. Only a few miles ahead of her was the EDMUND FITZGERALD, operated by the Oglebay Norton Company of Cleveland. The ship went down along the U.S.-Canadian border just outside of Whitefish Bay about 7:30 p.m. on November 10, 1975. (See Mariners Weather Log, 20 (1), pp. 46-47, January 1976.) Her crew of 29 men was lost. Later investigation showed her in three pieces on the bottom of Lake Superior (fig. 22); the cause of the loss had not been determined by fall 1976. Other storms brought freshwater fury to the Lakes on November 19-20 and 29-30. Cold air behind the latter storm center (984 mb) dropped the mercury to -28°F on the 30th in Minnesota.

Dates for the annual closing of the St. Lawrence Seaway and the Welland Canal were announced in October. On the St. Lawrence, the last traffic was scheduled for December 18. The Welland was scheduled to close on December 30. Misfortune nearly trapped two ships in the Lakes during the closing days of the St. Lawrence season. The IVORY NEPTUNE under Singapore flag was aground on the St. Marys River 35 mi below the Soo on December 11. About 1,500 tons of cargo were lightered off, and she was floated free in time to sail out of the Lakes system. The Indian VISHVA KIRTI also made it to the Atlantic after being aground in Green Bay on December 12.

Alternating periods of mild and cold weather during the first half of December prevented any real development of ice cover, with ice primarily confined to some northern bays and shallows of the St. Marys River. A small storm center moved from Alberta, Canada, to the Great Lakes on the 15th and 16th and set in motion a large reservoir of Arctic air. Rapid ice formation was initiated, and icebreaking assistance was rendered to the first vessel on December 17. The Coast Guard cutter WOODRUSH supported a voyage of the tug JOHN PURVIS and a barge on the Keweenaw Waterway in Lake Superior. During the next few days, Duluth Harbor became ice covered, as did the northern Lake Superior bays, the Apostle Island area, upper Green Bay and much of the lower Bay, the lower St. Marys River, Saginaw Bay, and portions of Lake St. Clair and western Lake Erie. The USCGC MESQUITE assisted the AMOCO INDIANA in Green Bay on the 19th.

The Ice Navigation Center operated jointly by the U.S. Coast Guard and the National Weather Service in Cleveland began operations on December 15. Ice reconnaissance flights were immediately ordered for the Upper Lakes on a routine basis. By the time the shimmering Christmas lights began appearing on the ships of winter, the Coast Guard had ordered their formal ice operation plans into action. "Coal Shovel," "Taconite," and "Oil Can" were begun at noon on December 23.

EXTENDED SEASON OPERATIONS

Persistent cold weather in January consolidated and thickened ice cover in most areas of the Lakes; however, the month was generally devoid of major

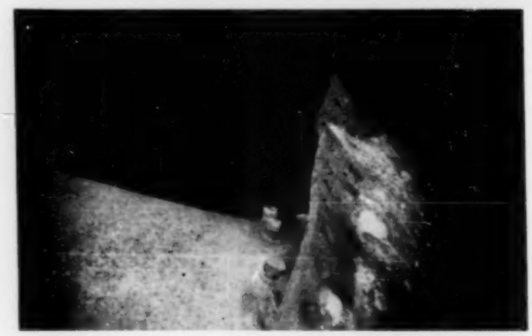

Figure 22.--Photo taken by the CURV III in May 1976 showing forward part of the stern section of the EDMUND FITZGERALD at the fracture. U.S. Coast Guard Photo.

Figure 23.--Mated tug and barge PRESQUE ISLE show a winter coat of ice as they battle the frozen lake in March. U.S. Coast Guard Photo.

storms. The first signs of what was to become one of the significant problems of the season appeared on January 10. During a normal season an ice "bridge" or dam usually forms across the lower end of Lake Huron near Port Huron. This bridge restricts the flow of drift ice from the lake southward into the St. Clair River. This season, because of shifting winds, frequent changes in temperature, and vessel transits, the bridge did not form completely. Drift ice continued to push into the river system, and ice jamming in the lower river produced flooding. The USCGC BRAMBLE was called in to break up the severe jam. She had considerable difficulty because the ice had no place to go in the restricted channel and was piled as much as 12 ft in some sections.

By midmonth St. Marys River and Green Bay had become mostly solid ice covered, as well as the Straits of Mackinac, Lake St. Clair, and western Lake Erie. Ice cover was also increasing out from the shorelines in most areas, including Whitefish Bay, Georgian Bay, Lake Huron, and central and eastern Lake Erie. Navigation became increasingly difficult, with much icebreaker support required in many areas, particularly the lower St. Clair River.

Over 60 icebreaking assists to vessels were made during the first 15 days of the new year. The IMPERIAL LONDON was the first boat assisted in Lake St. Clair, the CRISPIN OGLEBAY in Lake Erie, the A. H. FERBERT in the Straits of Mackinac, and the PRESQUE ISLE (fig. 23) in the St. Marys River. On January 13, U.S. Steel's Great Lakes fleet shifted operations from the down-lake port of Conneaut, Ohio, to southern Lake Michigan ports because of increasing difficulty in Lake Erie.

Continued cold weather through the end of January promoted continued ice growth and thickening. Buildout from the shorelines of ice cover occurred in most areas, with substantial increases of ice noted in northern Lake Michigan, Georgian Bay, and southern Lake Huron. Whitefish Bay and the North Channel became nearly 100 percent ice covered, with eastern Lake Erie primarily ice covered.

Increased ice in the Straits of Mackinac and the St. Marys River (fig. 24) prompted the deployment of the

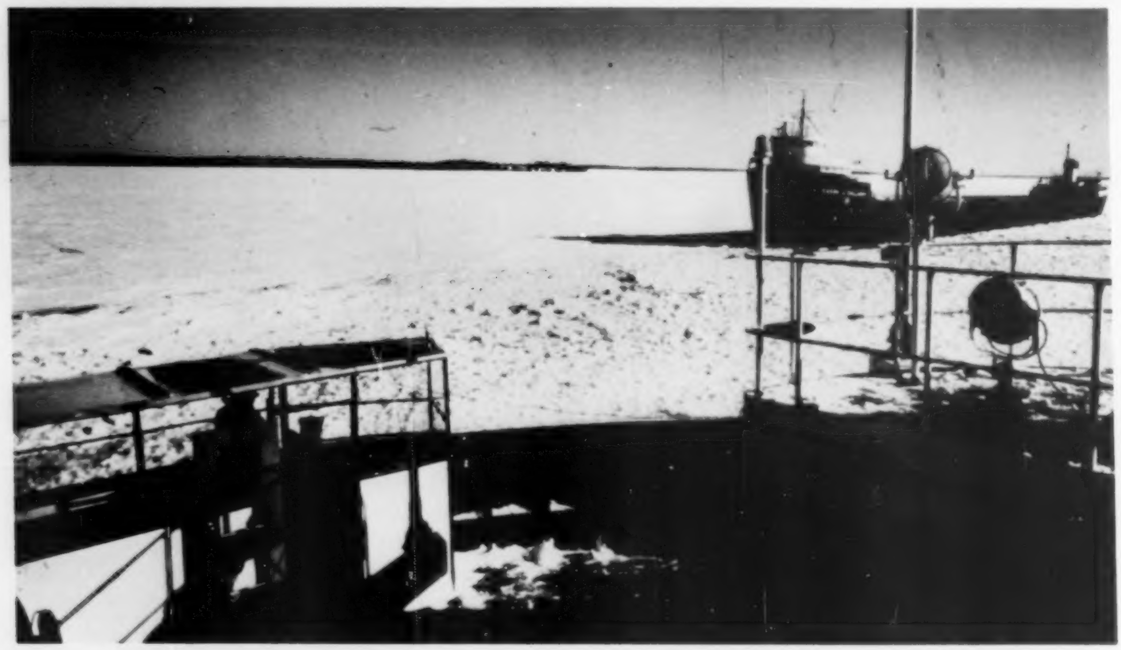

Figure 24.--The CASON J. CALLOWAY in the St. Marys River during March as seen from the stern of the MACKINAW. U.S. Coast Guard Photo.

major U.S. Coast Guard icebreakers WESTWIND and MACKINAW on January 16. Ice averaged 6 in in thickness through the Straits by midmonth with 1- to 3-ft ridges in the vicinity of Round Island. In the St. Marys, boats were reporting about 16 in of brash ice in the established track.

Meanwhile, in the St. Clair River the combination of increased ice in southern Lake Huron and the cold weather set the stage for a massive icebreaking effort. On January 15, the YANCANUCK became beset in Lake St. Clair bound for Detroit. She was assisted by the USCGC KAW. On the 16th, the BRAMBLE was called to work with the tug DARYL C. HANNAH and barge. By late morning, they were both beset in the ice north of Willow Point in the St. Clair River. The KAW moved northward to assist. By late afternoon, the BRAMBLE radioed that "in the past 8 hours, no progress made; lost ground when ice field moved down river." The Canadian icebreaker GRIFFON joined the team, and by sunset on the 17th, the commander of the operation in Detroit reported that ice was 8 ft thick. The BRAMBLE and GRIFFON returned to Port Huron, and the MACKINAW was requested. Another massive attempt at breaking the ice jam was made by the KAW, BRAMBLE, and MARIPOSA on the 18th. Progress was very slow until late afternoon when all of the units finally were able to batter their way clear of the jam. The GRIFFON sustained rudder damage during the effort.

The MACKINAW was ordered to the scene on January 20 and remained through the 25th. During this period, the MARIPOSA transited ice-covered Lake Erie to Buffalo to free a research vessel and the tanker SATURN. She fought widespread ridged ice and made only 50 yd/hr near Buffalo, but she freed both vessels with the help of the GRIFFON on January 28. Following the MACKINAWs departure, the USCGC SUNDEW moved from the Straits to the St. Clair River, and the JAMES HANNAH (sister tug to the DARYL HANNAH) also moved to the problem area. During a trip on January 28, the USCGC OJIBWA sustained over $5,000 damage when she was stopped by an ice ridge and the barge behind her pushed by the DARYL HANNAH ran up over her stern.

Ice jamming on the St. Clair River remained a problem throughout the first half of February with periodic flood relief icebreaking required. Navigation also remained extremely difficult. The WESTWIND was ordered into the area on February 3. On the 7th a new method to accomplish transits was tried with some success. The WESTWIND towed the oil barge while the company-owned J. A. HANNAH pushed her. Warmer weather finally arrived by mid-February with considerable easing of the ice pressure. The WESTWIND returned to her normal operating area in the Straits of Mackinac on the 16th.

Ice restrictions to navigation during January and February were not limited to the St. Clair River. Nearly continuous icebreaking was needed in many areas in the Upper Lakes. Shipping continued in upper Green Bay to Escanaba until January 19. The buoy tender MESQUITE routinely supported that operation. The WILFRED SYKES made the last run for ore.

Ice conditions in Lake Superior remained primarily stable during February. Considerable open water began to appear in the north-central portion of Green Bay, with most of the remaining ice around the periphery of Lake Michigan melting. Most of the deterioration took place in the latter half of the month.

Specialized support was again provided in the St. Marys River just below the locks at Sault Ste. Marie for the Sugar Island Ferry. Under the direction of the Corps of Engineers, an ice boom was constructed across the river with an opening for ship traffic. The boom was very successful in holding back most of the ice which previously broke loose from the shores following ship passages and clogged the channel area where the ferry operated. Twice during February strong winds from major storms forced ice over the boom and into Little Rapids Cut. On February 4, the

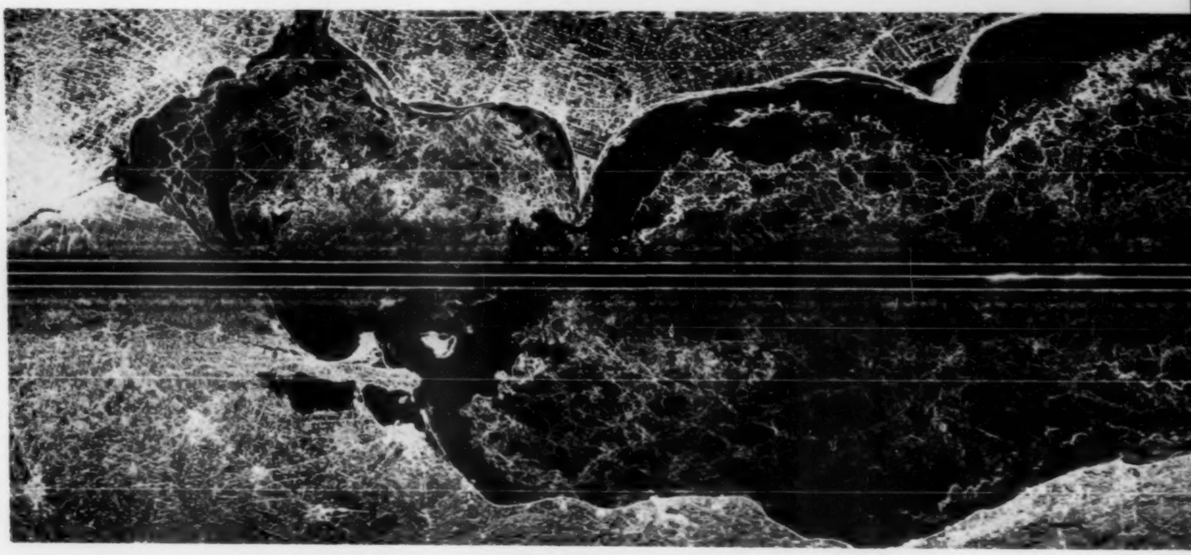

Figure 26.--This enlarged SLAR image shows the ice on Lake Erie on January 27, 1976.

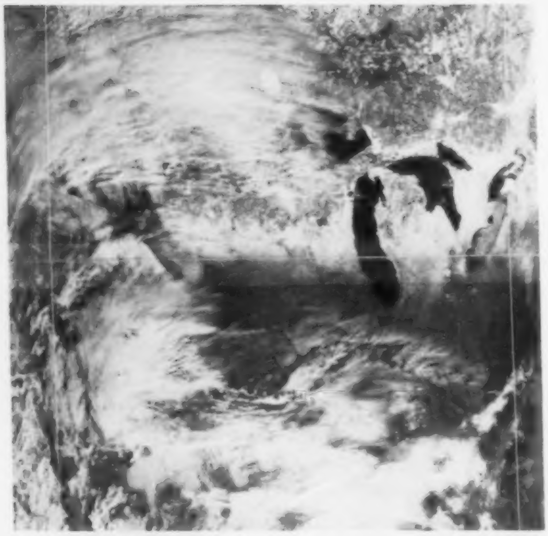

Figure 25.--NOAA 4 satellite photograph of Lakes region on February 14 shows extensive ice cover on Lake Erie, Lake St. Clair, the North Channel, most of Green Bay, the Straits of Mackinac and Whitefish Bay, and the St. Marys River.

ferry encountered her first problems due to the ice; minor delays also were experienced on the 25th.

Until milder weather arrived in late February, increased icebreaking was needed in Whitefish Bay, lower St. Marys River, and the Straits of Mackinac. Over 100 instances of direct assistance or preventative icebreaking runs were logged by the hard-working Coast Guard fleet during the first 20 days of February (fig. 25).

In support of the fleets of winter and the Coast Guard icebreaking forces, regular flights were made by the Coast Guard's C-130 aircraft using the Side-Looking Airborne Radar (SLAR) System (fig. 26) developed by NASA's Lewis Research Center. Flights were made almost every other day throughout the region from Lake Erie northward across Lake Huron or Georgian Bay and westward across the Straits and Lake Superior.

The aircraft was based in Cleveland. The radar signal was sent by a radio link to the NOAA GOES weather satellite and through the NASA Wallops Island receiving station by phone line to the Cleveland Ice Navigation Center (fig. 27). Photograph-like images of the ice coverage were received "live" on equipment in the Center, interpreted by a team of Coast Guard, National Weather Service, and NASA personnel, and sent back to the commercial fleet and icebreakers by radiofax (fig. 28). All of this was usually accomplished with less than a 2-hr lag time following completion of each flight route segment. The C-130 flew 47 SLAR missions from January 6 through April 15 accumulating 334.1 flight hours. Fifteen commercial boats and five Coast Guard ships were equipped to receive the radiofax data.

The unseasonably warm weather in February peaked on the 24th through the 29th. Record high temperatures for these dates included 59°F in Detroit, 62°F at Marquette, and 55°F in Duluth all on the 24th; 58°F at Alpena, 53°F at Duluth, and 55°F at Muskegon on the 25th; and 56°F at Marquette and 46°F at Alpena on the 26th. The heat wave was described by one National Weather Service meteorologist as a "once in a century event." The warmth made major changes in the ice, especially in the Lower Lakes. In Lake Huron, the little remaining ice by monthend was confined to the eastern shorelines. Much open water appeared in Lake St. Clair and all but the eastern third of Lake Erie.

The Poe Lock (fig. 29), the largest lock in the St. Marys River complex operated by the Army Corps of

Figure 27.--Great Lakes ice forecaster Daron Boyce (left) operates the tape recorder and MST Tim Murphy adjusts fine tuning on the image recorder which receive the SLAR signal from the NOAA GOES satellite. NASA Photo.

Figure 28.--Chief Larry Pierce traces a recently received SLAR image for transmission by facsimile to the ships. NASA Photo.

Figure 29.--A view of the Poe Lock during March 1976 from the bow of the USCGC MACKINAW. U.S. Coast Guard Photo.

Figure 30.--The ice in the St. Marys River at Sault Ste. Marie Locks as seen from the pilot house of the JOHN G. MUNSON. Photo by Daron Boyce.

Engineers at Sault Ste. Marie, was closed on February 26 after the CASON J. CALLOWAY backed into a safety boom on the west end of the structure (fig. 30). The ship sustained little damage, but the lock was closed about a week earlier than originally planned to repair the damage.

SPRING OPENING

March may not have "come in like a lion" as the saying goes, but it did not wait long to lash the Great Lakes with spring storms. An ice storm struck an area from central Lake Michigan across the lower Michigan peninsula to Lake St. Clair on the 2d. A major storm swept through northern Lake Michigan and the Soo area on the 5th followed by others on the 12th and 13th, 16th, 20th, 27th, and 30th.

Colder-than-normal temperatures during the first half of March in the north caused some new thin ice to form primarily in Lake Superior, but shipping lanes remained mostly open water. To the south, conditions ranged from stable to slow decay, although some increase in the thin drift ice was noted in Lake Huron. Saginaw Bay began breaking up, and Lake St. Clair became mostly ice free.

The tough spring ice of the northern lakes took its toll on commercial ships and Coast Guard vessels alike. On March 21, the MACKINAW in Whitefish Bay was icebreaking in close support of the PHILIP R. CLARKE. She was nearly stopped by a heavy ice windrow. The CLARKE was unable to stop in time and collided with the starboard quarter of the "Big Mac." Damage, including a crack in the MACKINAW's hull and main deck, totalled over $23,500. The next day the tug MARY E. HANNAH developed a 58-in crack in her port side while transiting the Straits in company of two of her sister tugs and the WESTWIND.

Generally above-normal temperatures during the latter part of March (fig. 31) resulted in deterioration of ice cover in all areas. In particular, only a few patches of ice remained in Lake Superior by monthend. Diminishing cover was beginning in northern White-

Figure 31.--NOAA 4 satellite photograph of Lakes region on March 22 shows wedge of ice in eastern Lake Erie and deteriorating ice in remainder of Lakes. Figure 32 shows the ice at the eastern end of Lake Erie as viewed by SLAR.

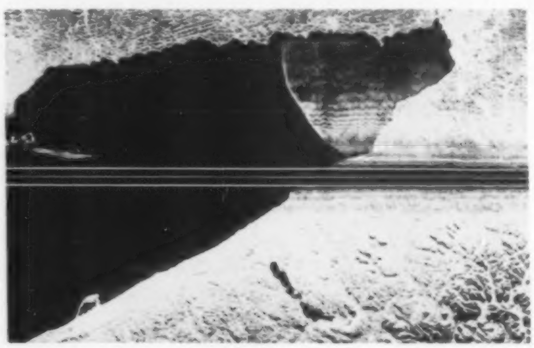

Figure 32.--SLAR picture of eastern end of Lake Erie vividly shows the ice in that part of the lake.

fish Bay and the Straits of Mackinac, with cover in Green Bay gradually decreasing. The Soo Locks down to Little Rapids Cut became ice free. Saginaw Bay's ice cover disappeared.

Most of the icebreaking attention in the last few days of March and into early April was focused on the Buffalo end of Lake Erie (fig. 32). For the first time in 3 yr a significant ice problem developed there as a result of spring southwesterly gales on the lake. The ice melted in most of the western sections of the lake, but the strong winds forced the ice from the central lake into the northeast sections and put it under considerable pressure. In recent years few ships have used Buffalo for winter layup, so there was little de-

Figure 33.--RARITAN breaks ice around ore boat in the St. Marys River. U.S. Coast Guard Photo.

mand for outbound transits. However, several ships were awaiting better conditions to make their first inbound runs. Coast Guard SLAR flights, Buffalo Corps of Engineers overflights, and helicopter flights from the Coast Guard Air Station in Detroit revealed considerable rafting and ridging throughout the area. A Corps tug reported 12-ft rafting in Buffalo Harbor on one probe of the ice field. Sample test borings farther out in the field showed ice thicknesses ranging from 2 ft to greater than 5 ft.

The USCGC OJIBWA and later the MARIPOSA worked diligently in cooperation with the Canadian ships GRIFFON and MCLEOD ROGERS for almost 2 weeks before conditions eased sufficiently to permit the first commercial traffic. The GRIFFON was the first vessel into Buffalo Harbor on April 10.

Farther down the Lakes, preparation was well underway to open the St. Lawrence Seaway. The USCGC NORTHWIND arrived in the Seaway from the Atlantic coast and made one complete pass of the system from March 31 into early April. The first westbound ship in the Seaway on April 3 was the Yugoslavian ALKA. She was also the first arrival in 1974. The Canadian LAKE MANITOBA was the first outbound vessel. On the Welland Canal, which opened April 1, the 730-ft CANADIAN LEADER was the first arrival downbound and the H. M. GRIFFITH upbound.

Steady deterioration of the remaining ice cover continued on the Upper Lakes in April. Ice virtually disappeared in deepwater areas of Lake Superior early in the month and in most bay areas soon after midmonth following unseasonably warm temperatures. The Whitefish Bay-St. Marys River area became free of significant ice by the 19th. The locks opened for a full 24-hr schedule on April 1. Navigational difficulty due to ice ceased in the Straits of Mackinac and all of Green Bay early in April and was mostly ice free by midmonth. Some ice remained in the North Channel and Georgian Bay until the latter weeks of the month.

The last assistance to the commercial fleet was rendered to the E.M. BARBER on the St. Marys River on April 12, the G.D. GOEBLE and CHICAGO TRIBUNE in Whitefish Bay on the 14th, and the GRACE and tug BELLE in Lake Erie on the 16th. On April 8, the last ice damage occurred when the USCGC RARITAN (fig. 33) was holed in her main hull while working in the St. Marys River. She was assisted by the KAW, ARUNDEL, and MACKINAW, but she was able to make it safely back to port under her own power.

The WESTWIND returned to her home port of Milwaukee on April 7 after 75 days, and the MACKINAW returned to Cheboygan, Mich., on the 15th after 90 days away from home.

SUMMARY

The 1975-76 ice season continued the trend of the previous four ice seasons during the formal demonstration program--it was warmer than normal (table

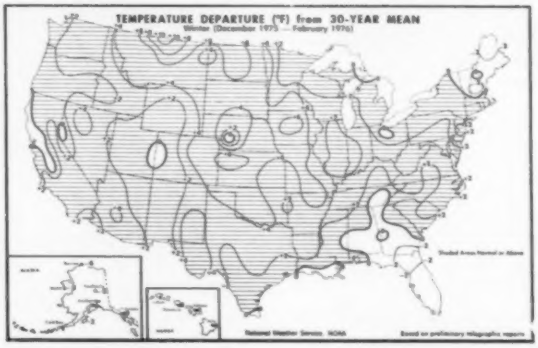

Figure 34.--Positive temperature departures cover practically all of the United States for the winter of 1975-76.

1) (fig. 34). It was unusual in that the temperature was quite variable during the winter. Periods of cold were usually followed by significant warmer periods. In many cases, these warm periods were marked by record-breaking temperatures. The net result was a significant relief in ice conditions. If the cold periods experienced during the winter had all occurred consecutively, it is doubtful whether navigation would have been able to continue year-round in spite of the faithful efforts of the Coast Guard's fleet of icebreakers, buoy tenders, and harbor tugs.

Another measure of the severity of the winter is the tabulation of freezing degree days. As shown in table 2, the maximum freezing degree days (FDD) averaged above normal (indicating colder than normal) in the southeast and near to slightly below normal in the northwest (near or a little warmer than normal). The greater-than-normal totals for the southeast, however, do not describe adequately the overall winter conditions. The apparent inconsistency results from the persistent very cold weather experienced during the latter part of December through early February. This also shows up readily in the dates that the maxima were observed. In all cases, these dates are about 2 to 3 weeks earlier than normal.

Table 1.--Departures from normal of Great Lakes air temperature (°F) for 1975-76 season

Month	Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario	Overall
November	+3.6	+6.6	+6.2	+6.0	+6.7	+5.8
December	-1.1	+2.0	+0.5	+1.0	-0.5	+0.4
January	-3.5	-1.3	-5.3	-4.8	-4.2	-3.8
February	+6.2	+8.0	+6.0	+7.1	+8.5	+7.2
March	-0.6	+4.8	+4.8	+6.6	+4.2	+4.0
April	+2.9	+2.4	+3.6	+1.1	+2.5	+2.5
November-April	+1.2	+3.8	+2.6	+2.8	+2.9	+2.7

The summary of icebreaking assistance in table 3 indicates that the hours spent and the number of miles traveled by the Ninth U.S. Coast Guard fleet were only slightly higher than last season. However, both vessel and cargo tonnage are lower than last year, indicating that more effort was expended per ton of cargo this season. The value of the cargo is much higher, due to better reporting by the companies involved in the program and to increased prices of all of the commodities, especially petroleum products, being shipped this season.

The number of vessels that participated in the extended season program was less than half of the previous season's total--71 compared to 152 during 1974-75. It was the longest navigation season ever on the Great Lakes. Since 1976 is a leap year, commerce was able to continue for 366 days--one day longer than year-round navigation during the 1974-75 season.

ACKNOWLEDGMENTS

Icebreaking data and casualty information were supplied by the Ninth Coast Guard District, Cleveland, Ohio.

Table 2.--Maximum accumulated freezing degree days + (FDD) in °F for 1975-76 season

Station	Maximum accumulated FDD 1975-76	Date	Normal maximum accumulated FDD	Date	1975-76 season versus normal
Duluth	2281	March 22	2281	April 3	+ 0 (Normal)
Marquette	1166	March 17	1361	March 29	-195 (Warmer)
Sault Ste. Marie	1757	March 22	1702	April 3	+ 55 (Colder)
Green Bay	1262	March 17	1416	March 26	-154 (Warmer)
Milwaukee	663	February 9	880	March 15	-217 (Warmer)
Muskegon	382	February 9	593	March 16	-211 (Warmer)
Alpena	1223	March 18	1164	March 28	+ 59 (Colder)
Detroit	610	February 9	*		+110 (Colder)
Toledo	593	February 9	500	March 2	+ 93 (Colder)
Cleveland	524	February 9	343	February 28	+181 (Colder)
Buffalo	608	February 9	489	March 18	+119 (Colder)
Rochester	600	February 9	586	March 18	+ 14 (Colder)

+ A freezing degree day figure is obtained for each site by subtracting the mean temperature for the day from 32°F. Cumulative totals are compiled with negative daily figures (melting degree days) included.
* Information not available--use Toledo data.

Table 3.--Summary of icebreaking assistance

	Operation hours in direct assistance	Mission miles	Total tonnage (GRT) of vessels assisted	Total cargo tonnage carried by vessels assisted*	Total value of cargo carried by vessels assisted*
FY 1971	4,080	14,101	3,453,708	2,520,152	$53,965,269
FY 1972	2,446.5	11,765.5	3,617,431	2,276,384	$61,862,404
FY 1973	1,341.6	9,494.2	2,076,701	1,470,995	$27,977,811
FY 1974	3,872.4	12,807.1	3,115,605	1,681,127	$45,640,302
FY 1975	2,575.2	11,275.4	5,788,909	3,662,653	$10,933,614**
FY 1976	2,775	11,586	4,553,832	2,937,083	$97,465,465

* Types of cargo carried: cement, coal, grain, iron ore, limestone, petroleum products, pellets, soy beans, steel, taconite, wood pulp, and general.

**This figure is not representative of the true value of cargo carried due to the lack of reported values.

Hints to the Observer

WIND-CHILL CHART: KNOTS AND KILOMETERS PER HOUR VERSUS DEGREES CELSIUS

This chart has been published several times previously, but the windspeeds were in miles per hour and the temperature in degrees Fahrenheit. This new wind-chill chart has been converted to knots and kilometers per hour versus degrees Celsius making it much more convenient for the mariner. It is Weather Service Form TA B-0-25 (6/76).

WS FORM TA B-0-25 (6-76)

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NOAA-NATIONAL WEATHER SERVICE WIND CHILL CHART

EQUIVALENT WIND CHILL TEMPERATURE °C

Wind speeds greater than 70 Km/Sec (35 Knots) have little additional chilling effect.

WIND SPEED Kilometers Per Hour														WIND SPEED Knots
70	-7	-14	-20	-27	-33	-40	-46	-52	-59	-65	-72	-78	-85	38
60	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-70	-77	-83	32
50	-6	-12	-18	-25	-31	-37	-43	-49	-56	-62	-68	-74	-80	27
40	-5	-11	-17	-23	-29	-35	-41	-47	-53	-59	-65	-71	-77	22
30	-3	-8	-14	-20	-25	-31	-37	-43	-48	-54	-60	-65	-71	16
20	0	-5	-10	-15	-21	-26	-31	-36	-42	-47	-52	-57	-63	11
10	5	0	-4	-8	-13	-17	-22	-26	-31	-35	-40	-44	-49	5
6	8	4	0	-4	-8	-12	-16	-20	-24	-28	-32	-36	-40	3
AIR TEMPERATURE °C	8	4	0	-4	-8	-12	-16	-20	-24	-28	-32	-36	-40	

This chart serves only as a guide to the cooling effect of the wind on bare flesh when a person is first exposed. General body cooling and many other factors affect the risk of freezing injury. The equivalent wind chill temperatures used on this chart are based upon a neutral skin temperature of 33° C. With physical exertion, the body heat production rises, perspiration begins, and heat is removed from the body by vaporization. The body also loses heat through conduction to cold surfaces with which it is in contact and in breathing cold air that results in the loss of heat from the lungs. This chart, therefore, does not take into account all possible losses of body heat. It does, however, give a good measure of the convective cooling that is the major source of body heat loss.

Tips to the Radio Officer

Thomas H. Reppert
National Weather Service, NOAA
Silver Spring, Md.

CORRECTIONS TO PUBLICATION, WORLDWIDE MARINE WEATHER BROADCASTS, 1976 Edition

The latest edition of Worldwide Marine Weather Broadcasts, dated May 1976, is now available and has been distributed to Port Meteorological Officers and ships participating in the Cooperative Ship Program. It is also available from Superintendent of Documents, Government Printing Office, Washington, D.C. 20402. Price: $2.00.

Recently, the coastal forecast areas were redefined for eastern and southern Florida. Figure 3, page 86, is amended as follows:

8. Savannah, Ga., to St. Augustine out 50 miles
9. St. Augustine to Jupiter Inlet out 50 miles
10. Jupiter Inlet to Key Largo out to Bahama Bank
10a. Key Largo to Dry Tortugas, including Florida Bay and Florida Straits
11. Cape Sable to Tarpon Springs out 50 miles

These changes also will require corrections to the areal coverage of the following radio stations:

Page 7--NMA Miami, Fla.
Page 37--NCH Miami, Fla.; NMB Charleston, S.C.
Page 38--WDR Miami, Fla.; NOK Key West, Fla.; WFA/KUZ385 Tampa, Fla.; NOF St. Petersburg, Fla.

ACKNOWLEDGMENTS

Thanks to Alan L. VanSickle, REO, SS AMERICAN ASTRONAUT: Juvenil H. Guaza, RO, M/N RIO LIMAY; Walter Sitarz, PMO, Miami, Fla.; and Robert Melrose, PMO, Panama Canal Zone, for recent information relative to the marine weather program.

Hurricane Alley

Dick DeAngelis
Environmental Data Service, NOAA
Washington, D.C.

The tropical waters of the North Indian Ocean and the Southern Hemisphere were quiet through July and August. This lack of tropical cyclones is not unusual since the North Indian Ocean is usually in the throes of the southwest monsoon while winter engulfs the Southern Hemisphere.

NEW PUBLICATION
TYPHOON HAVENS HANDBOOK

It is an awesome responsibility--the command of a ship. It sometimes involves the safety of a multimillion-dollar vessel. It always involves the safety of a crew. Some of the roughest decisions involve tropical cyclone encounters: whether to ride out the storm at sea or seek shelter and, if so, which ports would offer adequate shelter.

The U.S. Navy, actively engaged in the battle with typhoons since Halsey's World War II losses, has long been aware of these problems. And when the Navy works on a project, usually the entire maritime community benefits. Their latest effort in this battle is the Typhoon Havens Handbook for the Western Pacific and Indian Oceans by Samson Brand and Jack W. Blelloch (NAVENVPREDRSCHFAC Tech. Paper 5-76). It is a product of the U.S. Navy Environmental Prediction Research Facility at Monterey, Calif. This looseleaf book is a compilation of the many typhoon haven studies published by Monterey. The original papers, which were written for operational meteorologists, have been tailored into a decisionmaking aid for ship captains and others who have to face similar problems. The handbook is a long-term, continuing project. Evaluations of other ports will be published for future inclusion.

Section I discusses tropical cyclones--their characteristics, development, and effect on ships. Danger zones and warning services are described. An appendix offers a tropical cyclone climatology of the western North Pacific, Indian Ocean (both North and South), and the Australia-South Pacific region. Sections II through VI are the heart of the book. They evaluate the various harbors as havens against typhoons. Included is a description of the topographical features surrounding the harbor and a climatology of the tropical cyclones that have affected it. The climatology comes complete with probabilities of both the passage and intensity of a tropical cyclone. Next comes an analysis of the effects of the topography on winds, waves, and storm surges. The decision to evade or remain in port is discussed both pro and con. This discussion includes specific evasion tactics for the harbors being analyzed.

Fourteen areas have been studied, including harbors on Guam, Taiwan, Japan, the Philippines, and Hong Kong harbor. These make up sections II through VI of the book. These harbors and ones to be analyzed in the future are shown in figure 35.

Table 4 is a brief rating of various ports as ty-

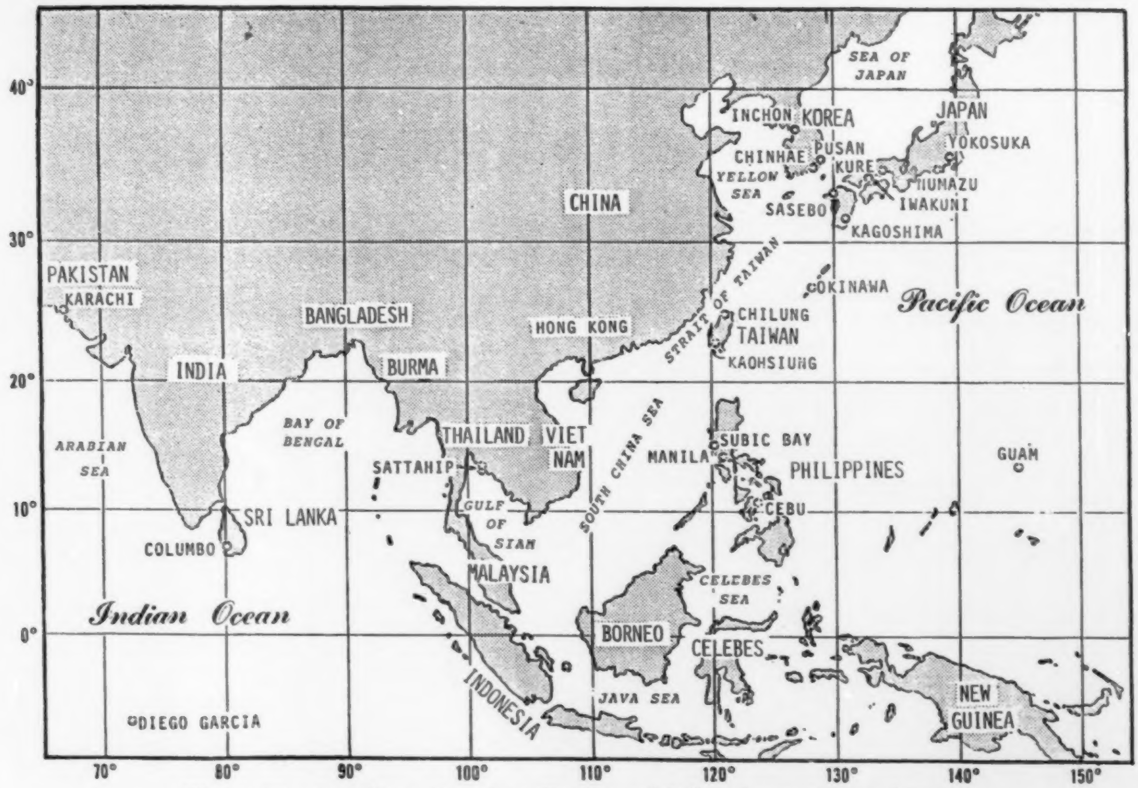

Figure 35.--Locations of western Pacific and Indian Ocean typhoon havens.

Table 4.--Ratings of selected western Pacific and Indian Ocean ports as typhoon havens

GUAM	
APRA HARBOR	POOR
TAIWAN	
KAOHSIUNG	POOR
CHILUNG(KEELUNG)	POOR
HONG KONG	
HONG KONG HARBOR	POOR
JAPAN	
YOKOSUKA	GOOD
NUMAZU OPERATING AREA	POOR
IWAKUNI	MARGINAL (but has easily accessible anchorages close by which are considered good)
KURE	GOOD
SASEBO	GOOD (except for carriers)
KAGOSHIMA	POOR
BUCKNER BAY, OKINAWA	POOR
NAHA, OKINAWA	POOR
PHILIPPINE ISLANDS	
SUBIC BAY	MARGINAL TO POOR
MANILA	POOR

phoon havens. These ratings will be explained in more detail in excerpts from the book, which we will carry in future columns.

For more information on this valuable publication, write to the Naval Environmental Prediction Research Facility, U.S. Naval Postgraduate School, Monterey, Calif. 93940.

TROPICAL CYCLONE NAMES

This list for the 1976-77 tropical cyclone season was kindly furnished by the National Meteorological Service of Reunion.

Agathe	Io	Rita
Brigitta	Jacqueline	Sonia
Clarence	Kiki	Therese
Domitile	Luce	Ursule
Emilie	Marylou	Valerie
Fifi	Nadine	Yvonne
Gilda	Odile	Zoe
Hervea	Patsy	

On the Editor's Desk

FREAK WAVE DATA COLLECTION

The Executive Committee of the Commission for Marine Meteorology of the World Meteorological Organization at its 28th session approved a recommendation that statistical information on the occurrence of "freak" waves (or troughs) should be collected and analyzed by one center which would publish the results. The United Kingdom kindly agreed to act as the international center for this purpose. The text of that recommendation follows.

Recommendation 22 (75-CMM)

FREAK WAVES

THE COMMISSION FOR MARINE METEOROLOGY,

NOTING:

(1) that freak waves, although a rare phenomenon, constitute a great danger to shipping,

(2) the need expressed by the International Chamber of Shipping for assessing the probability of freak waves occurring in any particular sea area,

CONSIDERING:

(1) that, although reports on freak waves are being collected and publicized by some countries, it would be very useful to accumulate reports of this phenomenon on an international basis in one centre, to enable a statistical analysis to be made in due course for any frequented sea area,

(2) that in national meteorological logbooks, apart from the columns for reporting waves, space is usually provided for remarks in which phenomena such as freak waves would surely be reported whenever encountered,

NOTING further with appreciation the offer of the United Kingdom to undertake the task of accepting reports from Members on freak waves, publishing reports of special interest, analysing the data in due time and publishing the results,

RECOMMENDS:

(1) that Members operating voluntary observing ships be invited

(i) to encourage marine observers to enter in meteorological logbooks detailed information on freak waves, as outlined in the annex;

(ii) to send such information when received by them to the United Kingdom Meteorological Office, Bracknell, for further action;

(2) that marine observers should use the following definition to record information relating to freak waves:

A freak wave may be defined as a wave of very considerable height ahead of which there is a deep trough. Thus, it is the unusual steepness of the wave which is its outstanding feature and which makes it dangerous to shipping. Reports so far available suggest that such waves have usually occurred where a strong current flows in the opposite direction to a heavy sea.

MERCHANT SHIP LOSSES HIGH IN 1975

According to the latest annual summary of casualty returns published by Lloyd's Register of Shipping in September, merchant ship losses reached their second highest level in 1975.

The figures take account of the loss of the Norwegian-owned, Liberian-registered 115,441-ton combination bulker BERGE ISTRA, which blew up and sank off the Philippines in December 1975. Total losses amounted to 336 ships of 995,261 tons--25 ships and 125,603 tons more than in 1974 and the highest level since the record year of 1971 when 377 ships totaling 1,030,560 tons were lost.

The greatest cause of loss was fire, accounting for 322,131 tons, including the BERGE ISTRA, the largest ship ever to sink. Wrecking came a close second, accounting for 315,428 tons of which the largest loss was the 48,252-ton Danish tanker JAKOB MAERSK. Also in this category was the 643-ton Panamanian cargo ship VERMONT, built in 1903 and the oldest ship to sink last year.

In other categories, 125 ships of 187,174 tons foundered, of which almost 33 percent were over 20 years old. The largest, however, was the 27,114-ton British tanker BRITISH AMBASSADOR, built in 1958.

Collision accounted for 119,107 tons, slightly less than in 1974, while vessels lost in unusual circumstances totaled 33,472 tons. Ships that just disappeared came to 13,949 tons.

This year's figures will have the additional boost of the loss of the VLCC OLYMPIC BRAVERY on the French coast in January 1976.

NOAA, UNIVERSITY SCIENTISTS PROBE WATERSPOUTS WITH AIRBORNE INFRARED LASER

Three scientists from Colorado were probing Florida waterspouts with laser beams aboard a small, single-engine plane during August and September.

The laser is part of a novel wind sensor that NOAA and Colorado State University are using to measure wind velocities in the seagoing funnels off the Florida Keys. Their study, sponsored by the Nuclear Regulatory Commission's Office of Nuclear Regulatory Research which hopes to use the results to understand severe weather phenomena, began August 16.

The wind-sensing system, designed at NOAA's Wave Propagation Laboratory, uses laser-generated beams of infrared radiation to gage windspeeds. It has been used previously to study dust devils, thermal plumes, and other weather phenomena on land.

The infrared doppler device uses a lidar (the laser equivalent of radar) to measure the velocity with which particles, such as droplets in a waterspout, are moving toward or away from it by bouncing light waves of known frequency off the target and measuring the frequency (doppler) shift of the return signal.

The Florida study will last from 2 to 4 wk depending upon how many waterspouts are located. When the National Weather Service radar on Key West detects offshore indicators of waterspout conditions, the researchers will be alerted (fig. 36.)

When a waterspout is spotted, the researchers

Figure 36.--Twin waterspouts ship along the water surface under dark clouds. Photo by Joseph H. Golden.

probe it from a safe distance of about one-half mi. Simultaneously, a specially instrumented aerobatic T-28 flies into the spout, obtaining on-the-spot velocities to compare with those obtained by remote sensor. The advantage with the doppler lidar is its ability to make measurements from the spray sheath near the water surface, where it is unsafe to penetrate, and near the cloud base.

The researchers hope to answer questions raised by previous investigation concerning vertical motions in waterspouts. Measurements from aircraft flying through waterspouts suggest central updrafts, contrary to the theoretical understanding of the thermodynamic processes involved. In fact, it is thought that a downdraft is more likely. While the doppler lidar can measure only the wind velocities parallel to the line of sight of the laser beam, making updrafts and downdrafts difficult to measure, it is believed that by flying close to the top of the spout and looking downward, any vertical winds can be detected.

LOW WATER HINDERS MOVEMENT OF BARGES ON MIDWESTERN RIVERS

The drought in the Midwest has lowered the depth of the Mississippi River and its tributaries forcing towboats to lighten their loads and decreasing the number of barges they push per tow.

River depths have decreased by as much as 8 ft in some areas, causing barges to touch bottom and go aground on sandbars. Operators are forced to move tows more slowly.

According to the Army Corps of Engineers, summer is normally the slack season for barge shipments, so the low water has not hurt business very much, but problems are expected to increase as export grain will be moving downriver in large volumes in the coming months.

The Mississippi, Ohio, Tennessee, and Missouri are not at historical lows according to the chief of operations at the Corps' St. Louis office, but the low water usually occurs in late October.

The Mississippi between Cairo, Ill., and Hannibal, Mo., is at its lowest point since January 1970. At St. Louis the river is 8 ft below normal. If below-normal rainfall continues, the situation will get worse.

The St. Louis division of the Corps has three dredges working on the river because of the low water--two more than usual for this time of year.

The narrower river channel results in towboats straying from the channel forcing barges aground. When the towboat works to free the barges, its propellers put a hump in the channel, necessitating dredge work.

One company has decreased barge drafts from 9 ft to between 8 and 8-1/2 feet. Each foot represents about 200 tons of cargo in a barge with 1,600 tons capacity. If you multiply this figure by 30 barges, it adds up to a large loss of tonnage. If the situation worsens, the towboats could be forced to reduce draft to 7-1/2 ft. Now the tows have to move extremely slow, get stuck at numerous spots, and sometimes have to break up the barges to clear some parts of the river.

NOAA ESTABLISHES OCEAN ENGINEERING OFFICE

NOAA has established an Office of Ocean Engineering. It will include the existing NOAA Data Buoy Office, the Office of Manned Undersea Science and Technology, and certain functions of the former National Oceanographic Instrumentation Center.

The new office reflects the importance to our nation of ocean resources and their sound use and environmental protection. Energy and other crucial offshore development require significant advances in fundamental engineering knowledge. That knowledge is now inadequate, and the lack of it contributes daily to the high cost of continental shelf development. Efforts to acquire this knowledge must be intensified.

The new office is considered of such sufficient importance that it will report directly to the NOAA Administrator and receive policy guidance from the Associate Administrator for Marine Resources.

Not only will it coordinate existing NOAA ocean engineering programs, it will initiate some of its own and will serve as a focus for technology transfer within the entire marine community, working closely with other Federal, academic, and industrial organizations.

A major element of the new office's effort will be an ocean instrumentation program useful not only to NOAA but also to other Federal and private marine programs. It will include research, development, and the standards, metrology, and calibration essential to data quality. In developing this national program, NOAA will work closely with the National Bureau of Standards.

SEA MISHAPS DOWN, TONNAGE UP

The Japan Maritime Safety Agency reported that accidents on the sea last year numbered the fewest since 1948, but nevertheless set a new record in total tonnage involved in the postwar period. This means that large vessels got involved in accidents in the sea last year.

In its annual report, the agency stressed that it needed more high-speed patrol ships and larger aircraft for surveillance of wider areas in the face of an increasing trend toward expanding territorial and exclusive fishing zones. It noted that the 12-mi territorial sea limit and 200-mi fishery zone have been generally accepted at past sessions of the Law of the Sea Conference.

Iceland and Mexico have already established 200-mi offshore exclusive fishery zones, and Canada and the United States have declared their adoption of similar zones next year.

The report said 2,421 ships were involved in accidents around Japan last year, down 68 from the previous year and the fewest since 1948 when the agency was founded. Of the total, 179 were foreign ships, down 29. The total tonnage involved marked a record 2,163,100 tons.

Dead and missing persons in the accidents totaled 419, down 211 from 1974. They included 58 foreigners, down sharply from the 226 of the preceding year.

The report also said that 22,702 crimes were committed aboard vessels, up 2,627 from 1974. Of them, cases of murder and battery-assault totaled 227, up 35.

There were 2,928 cases of sea pollution by ships, down 338 from 1974. The report pointed out the level was still high, despite Japan's efforts to control sea pollution in concert with the Intergovernmental Oceanographic Commission.

The report warned against a growing possibility of oil leaks and fires at sea owing to an increasing number of oil complexes in coastal areas and busy car-ferry and supertanker runs.

1976 BARGE FLEET MAKES PRUDHOE BAY

Fifteen oceangoing barges have completed a voyage from Tacoma, Wash., to Prudhoe Bay carrying a $200 million cargo of components to be used for developing Alaska's North Slope oil and gas fields.

The barge fleet began leaving the Point Barrow, Alaska, area on August 11 when ice pack conditions provided a limited annual access through the Beaufort Sea to Prudhoe.

The cargo aboard the barges totaled more than 60,000 tons and included units that form flow stations to extract and separate oil, gas, and water and reinject water and gas into the field and deliver oil into the trans-Alaska pipeline system.

The shipment also included living quarters for operating personnel as well as general cargo. In addition, the fleet included six barges carrying fuel development equipment for British Petroleum, operator of the western portion of Prudhoe field.

WEATHER BUOY STILL MISSING

Japan's ocean weather observation service has been hindered since one of its three "ocean buoy robots" and the observation equipment of another were stolen in December 1975 (Mariners Weather Log, 20 (2), p. 85, March 1976).

The Japan Meteorological Agency is still unable to determine who stole them, and has asked the International Criminal Police Organization to help investigate the case.

The theft came to light when buoy robot No. 4, set in the East China Sea far north of Okinawa, ceased to transmit radio waves last December. Crewmen of a ship sent by the agency found the complete set of observational instruments and the transmitter missing from the buoy robot. Circumstantial evidence showed that the deck of the buoy had been pried open to steal the instruments and the radio set.

Shortly later, buoy robot No. 5, positioned in the Pacific east of the Sanriku coast of the Tohoku Region, stopped sending out radio waves. Officials of the agency found the buoy missing from its position.

Since it was inconceivable that the ropes mooring the buoy to the anchor at the ocean floor snapped, they concluded that it had been stolen.

Each of the three buoy robots has a diameter of 10 m, weighs 40 tons, and cost about $235,000. They are designed to stand winds of 60 m per second (120 kn) and currents of 6 kn. The buoys were developed in 1968 for observations of marine meteorology. They measure air temperature, wind velocity, water temperature, waves, and other meteorological and oceanographic data.

Observation data collected by the three buoys were transmitted by radio every 3 hr to the Meteorological Signal Station in Kiyose, Tokyo. The data were used to study typhoons, seasonal winds, low pressures, and other phenomena.

The agency finds it difficult to collect sufficient data with the remaining buoy alone. The buoy is located in the Pacific south of Japan.

The theft case compelled the agency to revise part of its marine meteorological observation project started in 1973. To prevent a similar case, the agency has decided to equip the remaining buoys with burglarproof devices.

ADDRESSES FOR GREAT LAKES INFORMATION

For faster service, the National Ocean Survey requests commercial shippers and recreational boat and shoreline property owners interested in the Great Lakes to direct correspondence to the following offices:

- For Great Lakes charts, chart catalog, Great Lakes Pilot: Distribution Division, C44, National Ocean Survey, Riverdale, MD 20840.
- For present and historical Great Lakes water level information: Tides and Water Levels Branch, C3314, National Ocean Survey, 6001 Executive Boulevard, Rockville, MD 20852.
- For Great Lakes water level forecasts and the free Monthly Bulletin of Lake Levels: Corps of Engineers, P. O. Box 1027, Detroit, MI 48231.
- For matters relating to Great Lakes basic water research, including questions and requests for information on water quality, hydraulics and hydrology, ice and snow, and like subjects: Great Lakes Environmental Research Laboratory, 2300 Washtenaw Avenue, Ann Arbor, MI 48104.
- For general and historical information on the Great Lakes: Physical Science Services Branch, C513, National Ocean Survey, 6001 Executive Boulevard, Rockville, MD 20852.

SCIENTISTS LINK BUBBLES IN THE IONOSPHERE TO RADIO DISTURBANCES

Giant bubbles in the Earth's ionosphere may be the cause of a common disruption of radio and satellite communications.

With a colorful manmade cloud over Brazil, a rocket probe, and a portable radar, an international team of scientists has discovered a 6-mi-diameter bubble rising rapidly through the ionosphere and has developed a theory linking such bubbles to radio disturbances. The scientists made their find while trying to discover the cause of a phenomenon known as "equatorial spread F."

Long-distance radio signals are usually bounced off the ionosphere, the electrically charged layer of the stratosphere. In point-to-point communications through satellite relays, the signals pass through the ionosphere both on their way to and from the satellite. At certain times--usually at night at low latitudes in the summer--the signals become extremely distorted. This happens when the radio beam is reflected or scattered by small, dense clouds of electrons in the ionosphere. Different size "blobs" affect different radio frequencies, and the researchers were investigating the 3-m size that has been particularly troublesome to communications satellites.

The group has recently completed analysis of the results from a major field experiment at Natal, Brazil, in 1973 and has formulated a theory to explain how motions in the ionosphere could produce the irregularities that cause spread F.

From Natal, near the magnetic equator, a NOAA Javelin rocket was launched into the ionosphere during a certain time interval after sunset. At a height of 275 mi (460 km), the rocket released a cloud of metallic barium, a harmless substance that "colors" a patch of the ionosphere, allowing scientists to see otherwise invisible ionospheric motions with a telescope. Only 6 lb (2.7 kg) of the tracer were released, but it expanded into a cloud that appeared the size of the full moon to watchers on the ground.

The Sun's rays, which still illuminated the ionosphere, ionized part of the barium cloud. The resulting visible cloud separated into two glowing colors: a greenish component with no electrical charge that was picked up and carried by winds in the atmosphere and pink-colored ionized particles that responded to local electric fields. The pink part of the barium cloud rose rapidly after being released, showing a general upward drift of the ionosphere.

The rocket also carried instruments to measure the density of the plasma (ionized particles) which comprises the ionosphere. Normally, the ionization density increases smoothly with height to a peak density at an altitude of about 300 mi (500 km); but data from the rocket instruments showed extreme fluctuations in plasma density just below the level of maximum density, including one large region about 6 mi (10 km) thick where the plasma thinned out drastically, becoming 100 times more tenuous than the surrounding area.

Meanwhile, a radar on the ground detected a patch of irregularities rising rapidly through the ionosphere. Its initial velocity was over 840 mi/h (1,400 km/h), a rate even greater than the velocity of the barium cloud. From records of its trajectory, the scientists inferred that the patch had originated at the location of the hole detected by the rocket. They believe that the rapidly rising, 10-km hole they saw was like a bubble in the ionosphere. The smaller, 3-m irregularities that cause spread F, they surmise, may be due to turbulence on the edges of such bubbles.

The charge particles in the ionosphere are held up against the pull of gravity by lines of force of the Earth's magnetic field. As the Sun heats up the day side of the world, horizontal winds develop where heating is greatest to carry away the excess heat. These winds try to draw the ionized particles along, but the magnetic field lines hold them back. The conflicting forces generate an electric field, which pushes the ionosphere upward, above the level where it is stable. At night a reversed electric field arises

owing to cooling of the atmosphere, and the ionosphere is driven downward again. However, the ionosphere does not sink uniformly. While the dense plasma sinks in "globs," other areas of low density rise to the top. The smaller structures that distort radio signals, the group found, are apparently embedded in the edges of the large bubble.

Recently, other scientists working with the giant radar at Jicamarca, Peru, were able to see this process in even greater detail. They found what they called "fingers" or "plumes" rising in the ionosphere, which corresponded to the bubble that the Brazil study showed and confirmed the international group's theory.

UNIQUE FORTUNE ENCOUNTERS QUAKE

The UNIQUE FORTUNE's Ship's Weather Observations form copied in figure 37 was sent to the editor by Robert G. Quayle of the National Climatic Center. The significant feature of the form is the remark following the 0600 observation of February 4, 1976. The remark is as follows: "GMT 0930, Lat. 14°24'N, Long. 94°25'W, Vessel suddenly jumped twice, shuddered violently in calm sea."

Information from Carl A. von Hake of the National Geophysical and Solar-Terrestrial Data Center in Boulder, Colo., revealed that an earthquake of 7.5 magnitude on the Richter scale occurred in Guatemala at 0901:43.2 with the epicenter at 15.3°N, 89.2°W, about 190 km northeast of Guatemala City. The seismogram recorded at the Byerley Observatory, University of California at Berkeley, is shown in figure 38. The numbers at the top left indicate the date and time the record was started, the station number, and the component (vertical in this case). The record is wrapped around a cylinder and is continuous with one revolution per hour.

The beginning of the earthquake is indicated by the end of the relatively smooth line, 18 lines from the top. At that point the trace becomes very light as the stylus moved over large amplitudes. These continued for over an hour, and then the trace settled down again. The severity of the earthquake is determined by the amplitude of the trace using amplification and other factors for the sensing instrument.

This was the worst earthquake disaster in Central America this century. More than 22,000 persons were killed and another 75,000 injured. Over 250,000

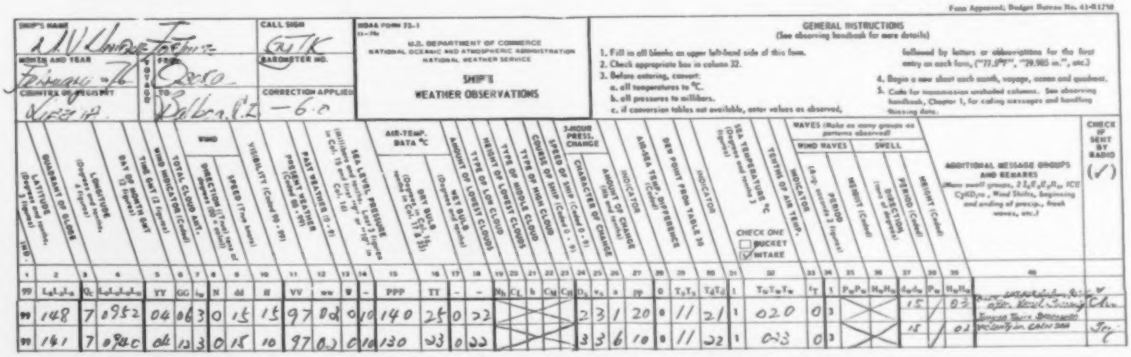

Figure 37.--The violent shudder in the remarks of the UNIQUE FORTUNE's weather log was later explained by the severe earthquake in Guatemala.

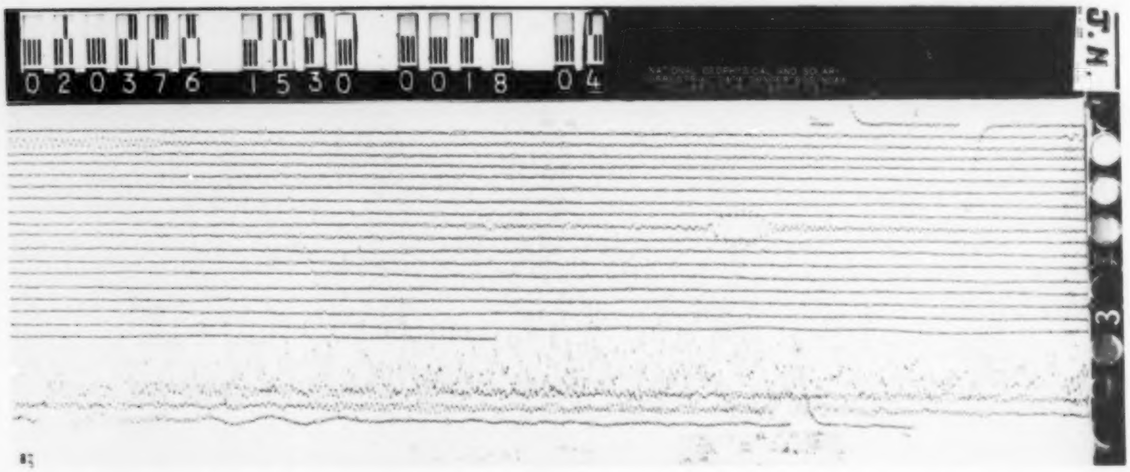

Figure 38.--The abrupt change on line 18 in the seismogram indicates the start of the quake.

houses were destroyed leaving 1 million people (20 percent of the population) homeless. Whole villages were demolished, and water, electricity, and communications were badly disrupted in other areas. Damage is estimated at from $4.5 to 6 billion. Massive landslides blocked roads and railroads. A rift over 160 km long was visible along the Montagua Fault.

NOAA STUDY SUPPLIES ANSWER TO SOLAR RADIATION RIDDLE

A solar radiation riddle posed by early satellite measurements now has been answered by newer satellites and NOAA scientists.

Early data from satellites revealed that the Earth does not reflect as much solar radiation back into space as had been believed. Scientists could not explain whether this extra energy was absorbed directly by the atmosphere or at the surface of the Earth.

During a recent global study of solar radiation, NOAA's Environmental Research Laboratories found that most of the excess is absorbed at the Earth's surface. This discovery is useful for establishing global radiation values for mathematical models of weather and climate.

It was found that a surprising 52 percent of the solar energy striking the planet is absorbed by its ocean and land surface, 19 percent is consumed by the atmosphere, and 29 percent is reflected back into space. Until now, on the basis of scattered, ground-based measurements, it was widely believed that no more than 47 percent of the solar energy reaching the Earth was absorbed by its surface, 17 percent intercepted by the atmosphere, and 36 percent reflected back into space.

The NOAA study is the first attempt, based on satellite and surface observations, to calculate how much sunshine reaches the Earth's surface on a global scale.

The study also showed that the Northern Hemisphere receives more solar radiation than the Southern Hemisphere. When the solar radiation for various zones of latitude was averaged, the maximum was received at latitude 15°N in April and moves northward with time to 30°N in July and August. The belt of maximum sunshine corresponds to a subtropical high-pressure zone where cloudiness is minimal.

Global observations were needed to obtain representative solar radiation conditions for application to numerical climate models. Prior to the advent of satellites, it was not possible to measure directly the global or latitudinal distribution of solar radiation reflected from the planet; but when satellites became operational, global sampling became a reality.

Early satellite measurements showed that the amount of sunshine reflected from Earth was smaller than expected from pre-satellite estimates. This new information spurred atmospheric scientists to question the assumed values of absorption of solar radiation at the Earth's surface and in the atmosphere. If less radiation is reflected by the planet than had been thought, then more of it must be absorbed at its surface or by the atmosphere.

The study suggests that absorption by the Earth's surface accounts for most of the discrepancy between pre- and post-satellite measurements of planetary reflectance. Pre-satellite estimates of how much energy the atmosphere absorbs were approximately correct--what was underestimated was the amount of solar radiation absorbed by the Earth's surface.

FIFTH ANNUAL REPORT OF NACOA ISSUED

The National Advisory Committee for Oceans and Atmosphere (NACOA), in a wide-ranging report, has advocated significant changes in the Nation's energy, marine, weather, and climatic programs.

Chairman of the 25-member group, charged with reporting to the President and Congress annually on the state of the Nation's marine and atmospheric programs, is William J. Hargis, Jr., Director of the Virginia Institute of Marine Sciences.

In a report transmitted to the White House by the Secretary of Commerce on September 28, NACOA recommended refocusing Federal atmospheric and oceanic planning and operational activities.

Major recommendations are:

--That an ad hoc task force be established by legislation to formulate a comprehensive marine affairs policy and plan pending development of a continuing coordinating mechanism. NACOA stated that oceanic events are developing more rapidly than are plans to cope with them.

--That the Nation explore and develop offshore oil and gas resources consistent with environmental safety and the need for maintaining strategic reserves; and that the process be reconciled with an economic atmosphere suitable for development.

--That Congress enact pending legislation for a program of climate watch, forecasting, and research under the coordination of the Secretary of Commerce.

--That NOAA receive responsibility for coordinating and managing a coherent Federal program of weather modification research and experimentation.

--That Federal funding for the National Sea Grant program be increased from $23 million to about $40 million per year over the next 3 to 5 yr; that its legislation be amended to free earmarked funds from matching criteria; and that its operations, goals, and priorities be studied and improved.

NACOA found "too much emphasis on haste" in energy research projects whose payoffs are distant in time and not enough on near-term possibilities. It recommended the establishment in the Energy Research and Development Administration of a Directorate for Oversight of Energy Research (DOER) reporting directly to the Administrator, whose function would be to give the Administrator technical advice on comparisons of alternatives.

The advisory group also termed inadequate Environmental Protection Agency pollution research programs addressed to long-term basic knowledge needs. It asked that longer term basic research receive more attention and that lead agencies be established for this purpose in three areas: the National Institute of Environmental Health Sciences for human health and disease; the National Oceanic and Atmospheric Administration for the atmosphere and oceans; and the Department of the Interior for plant and animal life on land and inland waters, with the Council on Environmental Quality leading a high-level interagency coordinating committee in the effort. NACOA also called attention to "serious deficiencies" in physiology-related diver research and in the development of decompression tables and recommended a $3.5 million

program toward faster, safer decompression and better understanding of the effects of undersea work.

The panel recommended that the Federal Aviation Administration and the National Weather Service review aviation weather needs and capabilities in the light of technological advances and update their priorities and agreements; that educational standards for training in use of weather information be improved, with emphasis on the effects of developing weather situations on flight control; that computer programs be used to screen deviating data on airway weather observations; that forecasts be analyzed after the fact; and that rapid weather hazard warnings be available to all pilots in flight.

Under NACOA's legislation, the Secretary of Commerce is required to respond to the report's recommendations. His comments, which reflect the views of all Government agencies involved, accompany the NACOA document to the White House and Capitol Hill.

PUBLICATIONS OF INTEREST TO MARINERS

U.S. NAVY MARINE CLIMATIC ATLAS OF THE WORLD, VOLUME III, INDIAN OCEAN

The U.S. Naval Weather Service Command has published a new climatic atlas, the U.S. Navy Marine Climatic Atlas of the World, Volume III, Indian Ocean. This volume, the second of the series to be revised and updated, was produced ahead of Volume II, North Pacific, because of the intense scientific interest in the Indian Ocean area. The North Pacific will follow this volume.

The atlas was prepared at the EDS National Climatic Center, Asheville, N.C. It can be obtained from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402. GPO Stock Number 008-042-00066-7. Price: $21.00

MARINE WEATHER REVIEW

The SMOOTH LOG (complete with cyclone tracks [figs. 43-46], climatological data from U.S. Ocean Buoys [table5], and gale and wave tables 6 and 7), is a definitive report on average monthly weather systems, the primary storms which affected marine areas, and late-reported ship casualties for 2 mo. The ROUGH LOG is a preliminary account of the weather for 2 more recent months, prepared as soon as the necessary meteorological analyses and other data become available. For both the SMOOTH and ROUGH LOGS, storms are discussed during the month in which they first developed. Unless stated otherwise, all winds are sustained winds and not wind gusts.

Smooth Log, North Atlantic Weather

May and June 1976

SMOOTH LOG, MAY 1976--Low-pressure centers traversing the North Atlantic this month were fewer than normal and were more concentrated during the last half of the month. The primary track off the U.S. East Coast was fairly well represented with the centers forming farther off the coast than usual. Another primary path from across the Great Lakes and north of the St. Lawrence River crossed the Labrador coast and moved eastward into the Norwegian Sea. Three centers crossed the North Sea, and one from midocean crossed the Iberian Peninsula.

The climatic monthly normal sea-level pressure for May has less definition of all the months. The gradient is very flat with only 10-mb difference between the 1012-mb Icelandic Low and the 1022-mb Azores High. The gradient or contrast this month was much greater. The Icelandic Low was 1000 mb near 60°N, 25°W, and the Azores High was 1026 mb near 32°N, 34°W. The pressure along the U.S. East Coast was near normal except for an anomalous 1011-mb LOW centered near Quebec. The 1016-mb isobar and zero departure isoline paralleled the U.S. East Coast and latitude 50°N across the water into the English Channel.

The major anomaly center was minus 12 mb centered with the Icelandic Low center near 60°N, 25°W. A negative 4-mb center was associated with the LOW near Quebec. The major positive anomaly was a large flat area that covered most of the ocean between latitudes 20°N and 48°N. The largest departure was 4 mb just south of the Azores Islands.

The upper-air circulation also was more intense with a tighter gradient than climatology indicates. There was an anomalous LOW south of Iceland ver-

tically alined with the more intense surface LOW. The trough that normally lies off the U. S. East Coast was retrograded to west of the Appalachian Mountains. As would be expected, there was a large 103-m negative height anomaly of the 700-mb surface collocated with the Icelandic Low.

There were no tropical cyclones. The season normally starts in June, but in the last 45 yr, nine are known to have occurred during May.

Extratropical Cyclones -- This was a Great Lakes storm. It formed as a frontal wave just north of Chicago on the 2d. At 0000 on the 3d it was 996 mb over the southern tip of Georgian Bay. A strong, narrow, cold high-pressure ridge extended south from Victoria Island in the Arctic. Strong west-northwesterly winds were blowing across the Lakes west of the low center. At 0000 the ELTON HOYT II measured 38 kn with 8-ft seas, and the ENDERS M. VOORHEES measured 35 kn and 5-ft seas on northern Lake Michigan. At 0600 the CHAMPLAIN measured 36-kn winds and 5-ft seas on Lake Huron. By 1800 the winds were blowing even stronger on eastern Lake Superior where the J. L. MAUTHE measured 39 kn with 15-ft seas.

By 0000 on the 4th the 993-mb LOW was over Labrador, and a new high-pressure center had broken off the narrow ridge and was moving southeastward relaxing the gradient over the Great Lakes. The LOW moved northward into the Labrador Sea on the 5th where it slowly deteriorated with no further problem to shipping.

This storm formed over northern Alberta, Canada, on the 3d. It moved across the Provinces bringing snow. Late on the 6th the 990-mb center moved over the Labrador Sea near Hamilton Inlet.

At 1200 on the 7th the LOW was centered near 56°N, 43°W. The AUGUST BOLTEN at 46°N, 49°W, was plotted as having 60-kn winds, yet the seas were only reported as 7 ft. Ocean Weather Station Charlie was in the warm sector of the occlusion with 15-ft seas.

By 0000 on the 8th the LOW had deepened to 978 mb near 59°N, 26°W. OWS Charlie had 35-kn gales and 20-ft seas behind the cold front. The occlusion was near OWS Lima which measured 40 kn and swells of 18 ft. At 1200 on the 8th the LOW moved over eastern Iceland and continued into the Greenland Sea.

Another center formed southwest of Iceland keeping the gradient to the south fairly tight. An Estonian ship, near 53°N, 26°W, reported 35-kn gales and 13-ft seas. Three other ships reported 15-ft swells. This center moved over Iceland and dissipated.

This storm was first analyzed near the juncture of the Missouri and Mississippi Rivers on the 13th. It was not until the 15th that its circulation became organized as it moved over the Maritime Provinces. At 0000 on the 16th the 996-mb LOW was near 45°N, 58°W. At 1200 the first gale-force wind was reported by the NATHANAEL GREENE with 15-ft seas near 40°N, 56°W. At 0000 on the 17th the STADT WOLFSBURG, north of the center, found gales, and the drilling ship VGBZ measured 40 kn and 15-ft seas west of the center. At 1200 the HOLSTENDAMM in the vicinity of 32°N, 50°W, reported a 70-kn wind with a rain shower along the cold front. Southwest of the center, the MONSUN also had rain showers with 50-kn winds and 21-ft seas.

The LOW moved toward the southeast, an odd direction, from the 16th to the 18th. At 1200 on the 18th, the EAGLE CHARGER found 40-kn gales and 10-ft seas at 36.3°N, 42.1°W. At that time the storm had turned eastward and northeastward on the 21st. Generally the winds were less than gale force with 12- to 15-ft seas near the front. Late on the 21st, the EXPORT PATRIOT (47.6°N, 30°W) was hit by 45-kn winds.

On the 22d the storm regenerated as its energy was reinforced by a cold front. At 0600 the EXPORT PATRIOT at 48.4°N, 24.5°W, fought 50-kn winds. At 1800, the 992-mb LOW was near 49°N, 25°W. The PROYV was now near 47°N, 30°W, and battling 40-kn winds and 20-ft seas. The STEFAN BATORY, at 51°N, 25.5°W, was only a few miles west of the 994-mb center at 0000 on the 23d, with 40-kn winds and 13-ft seas. The PROYV was slowly cruising northward and again reported 40-kn winds and 20-ft seas at 0600.

Early on the 24th the storm was moving due north, and a secondary LOW had formed in the southeast quadrant. The AMERICAN COURIER at 59°N, 10.2°W, reported 45-kn gales. On the 25th the storm turned northwestward toward the coast of Greenland and dissipated.

A weak LOW moved over Newfoundland and to sea on the 24th. On the 25th a frontal wave developed southeast of Cape Race. At 1200 it was 996 mb and growing. A ship reported 40-kn gales and 20-ft seas south of the center.

At 0000 on the 26th the 980-mb storm was centered near 52°N, 35°W. The center was very near Ocean Weather Station Charlie which measured 40-kn winds and a pressure of 981.4 mb. The ROMAN PAZINSKI was buffeted by 47-kn winds ahead of the front near 41°N, 34°W. At 0600 Charlie measured 44-kn winds and 20-ft seas. In the same general area two other ships estimated 40-kn winds. The FEDERAL ST. LAURENT was near 54°N, 25°W, with 35-kn winds and 21-ft seas. At 1800 the MOSEL EXPRESS, at 50.8°N, 24.6°W, had 37-kn winds and 25-ft swells.

The LOW was now almost stationary. OWS Charlie was still recording 40-kn winds at 0000 on the 27th. The seas and swells were 23 ft. By 1200 the wind had picked up to 45 kn and the seas to 28 ft. The IDEFJORD, near 54°N, 35°W, also had 44-kn winds and 23-ft seas.

On the 28th the LOW started to drift southward and weaken, and on the 29th another LOW approached from the west and quickly absorbed the old circulation.

A weak but large low-pressure area dominated the Gulf of Mexico on the 22d. On the 24th, the CARBIDE TEXAS CITY and the EXXON HUNTINGTON had gales off the Florida coast and seas to 15 ft. The 994-mb LOW drifted eastward and was over the Gulf Stream by the 25th. At 0000 the EB16 interrogation indicated 35-kn winds. At 1200 a ship, near 38°N, 69°W, fought 35-kn gales. At 1200 on the 26th the 1001-mb LOW was near 40°N, 60°W. At 1800 the QUEEN ELIZABETH 2 reported 26-ft swells near 42°N, 62°W.

By 1200 on the 28th the 993-mb LOW was near 47°N, 42°W. The SEA-LAND RESOURCE at 45.5°N, 35.4°W, had 42-kn gales with waves of 18 ft. The

LOW passed about 150 mi south of OWS Charlie on the 29th. The SEA-LAND RESOURCE now had 45-kn winds, 10-ft seas, and 23-ft swells. At 1200 on the 30th the DART AMERICA at 47.9°N, 24°W, had 54-kn winds and 25-ft waves. On the 31st another LOW approached from the west, and by 1800 this LOW was only a trough.

Casualties--The 58,000-ton Dutch tanker CAROLYN JANE was dragged aground at Malta by a storm early in the month. The 4,734-ton UNITED FORTUNE ran aground in the Mississippi, near New Orleans, on the 10th due to a wind and rain storm.

SMOOTH LOG, JUNE 1976--There were major differences from climatology in the paths of the storm centers this month. According to climatology, the primary tracks are: Over Lake Superior to the Gulf of St. Lawrence, Lake Winnipeg across southern Hudson Bay where it splits toward the Davis Strait and the Labrador Sea, Cape Cod to Belle Isle then toward the Faeroe Islands, and from about 180 mi southeast of Kap Farvel to northwestern Iceland.

This month the primary paths were concentrated between Lake Superior and Lake Winnipeg to James Bay. Only three centers survived to reach the sea as they crossed Quebec. A primary path moved southeastward from Ungava Bay to tne vicinity of 50°N, 35°W, where it curved sharply northward toward Iceland. Another originated west of Nova Scotia, moved eastward to midocean, and then northeastward toward the Faeroe Islands. No major cyclone center crossed the United Kingdom or the European continent to the south. Only one small cyclone occurred over the Mediterranean Sea.

The sea-level pressure pattern helps explain the behavior of the cyclone centers. The normal pressure pattern indicates two weak 1009-mb Lows along 60°N at 35°W and 60°W. The Bermuda-Azores High at 1024 mb is centered near 32°N, 35°W, with ridging into the southeastern United States and into western Europe.

This month the Icelandic Low had one 1001-mb center near 60°N, 30°W. The High was 1025 mb at 30°N, 50°W, with a 1024-mb subcenter near 40°N, 20°W, and another 1023-mb subcenter near 48°N, 05°W. These differences resulted in higher pressures over western Europe and the eastern United States.

The anomaly centers reflect the differences described above. There was a minus 9-mb center near 58°N, 30°W. There were plus 5-mb centers near 36°N, 60°W, and the English Channel. The high pressure over northwestern Europe brought high temperatures and dry weather. Many areas suffered drought conditions.

The 700-mb upper-air pattern corresponded with the surface. An anomalous Low was centered near 59°N, 37°W, and a closed High was near 30°N, 51°W. There was more ridging than normal over the eastern United States and a very pronounced ridge over western Europe.

There were no tropical cyclones this month. On the average one will occur every 2 yr.

Extratropical Cyclones--There was only one severe storm this month, and it occurred during the middle of the month. Most of the cyclones were weak, generating only minimal gales or less.

The first storm of any significance formed as a frontal wave over Maine on the 1st. The first gales were reported on the 2d. The FEDERAL SCHELDE at 48.7°N, 44.2°W, encountered 43-kn gales, and the DART AMERICA at 44.3°N, 54.9°W, braved 40 kn. The AMERICAN CHAMPION at 47.3°N, 34.5°W, had 40-kn gales, 10-ft seas, and 33-ft swells at 1200.

At 0600 on the 3d, the AMERICAN CHAMPION was at 44.2°N, 41°W, with 35-kn winds, 10-ft seas, and 25-ft swells. At 1200 the LOW was 983 mb at 57.5°N, 35°W. Ocean Weather Station Charlie measured 38-kn winds at 0600, and by 1800 the swells had increased to 20 ft. Early on the 4th, the LOW was moving northward toward the Denmark Strait. The NANOK S. was south of Iceland with 44-kn winds, and the SOMERSET MAUGHAM was north of the Island with the same winds. At 1800 a trio of Icelandic fishing vessels all reported 37 kn north of the Island. At that time the LOW was stationary off Keflavik and dissipated on the 5th.

This rough weather was not associated with a closed LOW. There were indications of small, stable frontal waves along the front. The front associated with the previous LOW crossed north Florida on the 4th and remained essentially stationary off the east coast of the United States paralleling the Gulf Stream. An elongated HIGH north and west of the front was slowly pushing eastward. This resulted in a tight gradient northwest of the front and relatively strong northeasterly winds.

On the 4th, the GULF QUEEN at 39.4°N, 64°W, had 35-kn gales and 13-ft seas. On the 5th, five ships reported 35-kn gales between latitudes 34° and 38°N and longitudes 69° and 77°W. The seas ran from 6 to 17 ft, with the CARBIDE TEXAS CITY reporting the 17 ft at 37.1°N, 74.6°W, at 2300. The other four ships were: AFRICAN MERCURY, BALTIMORE, HESS VOYAGER, and JACKSONVILLE. At 0000 on the 6th, the SEA-LAND RESOURCE found 40-kn gales and 13-ft seas at 38.4°N, 67.2°W.

On the 7th, a LOW formed east of Florida and another moved eastward across southern Canada to the Maritime Provinces. The HIGH split and retrograded westward, leaving only a weak gradient as the front dissipated.

This was one of the few storms that originated far inland and survived to menace shipping. It was first analyzed east of Lake Winnipeg at 1200 on the 10th and raced eastward as a frontal wave. When it moved over Newfoundland and the water at 1200 on the 11th, it started deepening rapidly. At 1800 the UZHS at 51.5°N, 37.7°W, had 40-kn southeasterly winds. By 1200 on the 12th, the 972-mb storm was near 59°N, 30°W. Ocean Weather Station Charlie was riding out 36-kn winds and 18-ft seas, while the KIMOVSK at 53°N, 26.8°W, enjoyed 40-kn southerly winds and 15-ft seas. At 1800 the QUEENSGARTH at 53.7°N, 30.4°W, had 46-kn winds and 20-ft seas.

On the 13th the 980-mb LOW was passing south of Iceland, and Ocean Weather Station Lima was pounded by 40-kn winds and 23-ft swells. On the 15th the storm moved inland over Norway, having traveled shore to shore.

Monster of the Month--This was the next frontal wave on the cold front that produced the storm described above. At 0000 on the 12th, it was over Maine. Only 35-kn gales were found. It deepened from 992 mb at 0000 on the 13th to 977 mb by 1200 near 47°N, 49°W. At 0000 on the 13th, the CETRA COLUMBA (39.5°N, 46.5°W) fought 56-kn winds from the southwest. Two other ships in that area reported gales in the 40-kn category. At 1200 the report from the CETRA COLUMBA indicated a devastating 90 kn. A SHIP, about 300 mi southwest of the center, was sailing into 30-ft swells. A ship north of the center which may have been the ORE METEOR rolled with 40-kn winds and 20-ft seas. The YOUNG AMERICA (41.9°N, 56.5°W) fought 40-kn winds, 17-ft seas, and 23-ft swells. The SHERMAN measured 42 kn and 8-ft seas at 37.2°N, 47.9°W. At 1800 the ETROG at 45.1°N, 55.2°W, contended with 50-kn winds and 16-ft waves.

At 0000 on the 14th, the LOW was 970 mb near 50°N, 42°W, and the NEW ENGLAND HUNTER at 43°N, 47°W, was mauled by 70-kn winds and 33-ft waves. The ORE METEOR at 50°N, 50°W, was plowing into 55-kn winds, 23-ft seas, and 26-ft swells. At 1200 the POST RUNNER near 44°N, 39°W, wallowed in 60-kn winds, 20-ft seas, and 30-ft swells. Winds of 40 kn and seas of 20 ft were reported by several ships. The GUNTHER SCHULTE had 44-kn winds and 16-ft waves at 1800, and the AMERICAN LEGACY was heading into 30-ft swells.

One of the biggest factors of this storm was the high seas, especially for an extratropical summer storm. At 0000 on the 15th, Ocean Weather Station Charlie hosted 26-ft seas with 40-kn winds, and a ship near 53°N, 43°W, had 23-ft seas. North of the center, the MISIGSSUT (60.3°N, 42.2°W) had 52-kn northerly winds. Near 50.7°N, 33.2°W, the DLHO also had 52-kn winds, but from the southwest, and by 1200 they had increased to 60 kn. The C. P. TRADER at 51°N, 40°W, was sailing with 40-kn winds, 20-ft seas, and 26-ft swells.

On the 16th the storm was weakening and curving eastward. Late on the 17th it disappeared from the analysis.

Many of the 125 yachts in the singlehanded yacht race from Plymouth, England, to Newport, R.I., which started June 5 were probably involved in this storm. As of July 15, all but 7 had been heard from, 48 had finished, 43 had retired from the competition, and 34 (including the 7) were still to arrive at Newport.

The 14-m yacht LA GAULOISE was dismasted and reported in danger of sinking on the 14th. Three ships--the ATLANTIC CONVEYOR, BASTO, and DART ATLANTIC--diverted to assist. The lone crewman was picked up by the ATLANTIC CONVEYOR. The 62-ft trimaran SPIRIT OF AMERICA turned back to England when about halfway across the Atlantic on the 17th after a series of gales and high waves smashed a hole in one of the crossbeams. The skipper reported encountering winds of 70 to 80 kn and seas to 30 ft during the 12 days westbound. At one point 4 days out strong gusts blew down the main sail.

A freighter found the 38-ft sloop GALLOPING GAEL empty and adrift; there was no indication of what had happened to the skipper.

This low-pressure system and storm lasted from the 12th to the 28th. It originated over North Dakota and moved northward over Manitoba where it turned eastward. It then moved eastward across Canada as a fairly strong storm. On the 17th it crossed the Labrador coast with a large circulation, but part of it broke off on the 18th and moved up the Davis Strait as the LOW passed south of Kap Farvel. The storm almost dissipated on the 20th as it made a cyclonic loop during the 20th, 21st, and 22d. During this time, the highest winds plotted were in the minimal gale category.

On the 22d and 23d, another LOW came off the Labrador coast and moved around the southern periphery of the LOW. The ORE MERCURY at 52.2°N, 21.9°W, encountered 50-kn winds and 20-ft swells at 1200 on the 23d.

On the 0000 chart of the 24th, the second LOW had been absorbed into the circulation of the original LOW. Ocean Weather Station Lima measured 40-kn winds and 20-ft seas. At 0600 a buoy at 61.8°N, 29.1°W, reported 39-kn northerly winds. At 1200 Lima was still battling 20-ft waves, and the NANOK S. had 52-kn winds out of the south.

On the 25th the 981-mb storm moved over Iceland into the Norwegian Sea. It was gradually weakening and disappeared over the Barents Sea on the 28th.

Casualties--The tug SALLY L. capsized and sank in the Houston Ship Channel during a storm on the 1st. The 9,171-ton POINTE NOIRE touched the bank of the St. Lawrence Seaway in fog early on the 4th.

The barge NEPCO 140 carrying 6 million gal of oil struck a fog-shrouded Comfort Island in the Thousand Island area of the St. Lawrence Seaway. It was estimated that 250,000 gal of oil were spilled into the river.

Smooth Log, North Pacific Weather

May and June 1976

SMOOTH LOG, MAY 1976--The number of storm tracks was near normal, but they were more widely dispersed than usual. The two primary source areas, southern Japan and northern Manchuria, were fairly well concentrated, but once over the water, their paths scattered. In general the storms from southern Japan moved eastward between latitudes 35° and 45°N to midocean, then turned northeastward into the Gulf of Alaska. The Manchurian storms crossed the Sea of Okhotsk and then into the Bering Sea.

The pressure pattern and centers were nearly a duplicate of climatology except for central pressures. The Aleutian Low was about 3 mb lower and the Pacific High 4 mb higher than climatology. The primary LOW was 1006 mb, near 57°N, 150°W, centered in the Gulf of Alaska. Two 1007-mb subcenters were over the Bering Sea. The Pacific High, at 1027 mb, was centered near 32°N, 145°W.

The anomalies were not large. The deepest was minus 7 mb in the Gulf of Alaska near 55°N, 141°W. There was a plus 4-mb center at 33°N, 150°W.

The upper-air pattern was also near normal with a slightly tighter gradient than climatology because of more intense central pressures. The flow across the water was predominantly zonal with major troughs off the west coast of North America and another off the east coast of Asia.

There were two severe typhoons, Olga and Pamela.

Extratropical Cyclones--This storm was over the Sea of Japan on the 1st. By 1200 on the 2d it was 992 mb near 40°N, 159°E, with most reports of only minimal gales, but the PEARL VENTURE at 39.7°N, 145.5°E, found 48-kn winds and 16-ft waves. Swells were running about 10 ft in the southeast quadrant. At 1200 on the 3d the cold front passed a ship, near 37°N, 174°E, treating it to obscured skies, heavy drizzle, 40-kn gales, and 16-ft swells. At 0000 on the 4th the LINGAYEN, near 40°N, 178°E, had a thunderstorm with 40-kn gales associated with a trough behind the front. The PACIFIC VENTURE, northeast of the center at 49.4°N, 173.3°W, measured 40-kn winds and 16-ft waves. Several other ships reported 35-kn gales.

By 0000 on the 5th the 977-mb LOW was centered near 50°N, 166°W. A Japanese-registered ship, near 46°N, 172°W, had 45-kn westerlies, 20-ft seas, and 23-ft swells. The PRESIDENT PIERCE at 43.4°N, 167.4°W, had 40-kn southwesterly gales and 23-ft

As the storm approached the Gulf of Alaska on the 6th, it was decreasing in intensity, and on the 7th only a depression in the isobars indicated its existence.

The first indications of this frontal wave were ship reports south of Kyushu and steady rain over the Island late on the 2d and 3d. The wave moved northeastward, south of the islands, as a weak system until the 6th when it started deepening. At 0000 the EASTERN JADE found 35-kn gales and 12-ft seas near 35°N, 156°E.

At 1200 on the 7th the storm had a central pressure of 968 mb. There were no ships plotted south of the center, but the gradient would indicate gale-force or higher winds. The gale tables indicated that the CAMARA was at 42.5°N, 179.7°W, and measured 44-kn winds. At 0000 the ships were reporting. The JAPAN POPLAR was swept by 50-kn winds near 46°N, 177°W. The following four ships all reported 45-kn gales and the highest waves indicated: CAMARA - 18 ft (43°N, 176°W); PACBARON - 23 ft (44°N, 176°E); JAPAN CEDAR - 23 ft (50°N, 166°W); and an unidentified ship - 13 ft (44°N, 169°W). At 0000 on the 9th the EASTERN HILL was about 400 mi southwest of the 974-mb storm with 50-kn winds and 21-ft seas. Another ship 500 mi due south fought 45-kn winds and 20-ft seas. At 0600 the MELLON, 550 mi southwest of the center at 41.9°N, 158.8°W, measured 48-kn winds and 36-ft seas. Not far away, the ANNA MAERSK logged 20-ft seas and 25-ft swells. At 1200 the SAJANSKIE GORY was sailing into 45-kn gales northwest of the center.

On the 10th the storm started the dissipation process over the Gulf of Alaska but was still able to treat the MEDELENA to 38-kn winds, 10-ft seas, and 23-ft swells near the edge of the storm at 47.1°N, 156.4°W. On the 11th, it disappeared.

At times in meteorology the exception is the rule. A front stretched between two fairly strong cells of the Pacific High. South of the western cell, which was 1030 mb near 36°N, 172°E, a wave developed on the front late on the 10th. It moved eastward against the surface wind flow. At 1800 on the 11th, the MONTANA found 35-kn gales and 15-ft seas north of the wave at 33.2°N, 166.8°E.

By 0000 on the 12th, the 1010-mb LOW was at 32°N, 172°E. A ship with the last three call letters YPK was washed by heavy rain with 40-kn winds. At 0300 the LETITIA LYKES entered a special observation of 60-kn winds with continuous moderate rain near 35.5°N, 169.1°E. The waves were 18 ft. At 1200 the KOYU MARU contended with 40-kn gales.

The LOW at 1012 mb was pushing between the two HIGHs, on the 13th, but could not break through and perished by the 14th.

A low-pressure center moved over the Sea of Japan from North Korea on the 16th. As it crossed the tip of Kamchatka on the 18th, a new center developed in the trough south of the original center. At 1200 on the 20th, the 986-mb LOW was near 52°N, 170°E. Ostrov Beringa measured 35-kn northerly winds. At 0000 on the 21st the HOYO MARU was about 200 mi southwest of the center with 40-kn gales and 10-ft seas and swells. By 1200 a new LOW had formed in the eastern quadrant north of Adak Island. The PRESIDENT TRUMAN at 51.9°N, 172.3°E, had 55-kn westerly winds. The LOW disappeared on the 22d leaving a southeasterly oriented trough east of the Alaska Penin-

sula. The new LOW became the primary storm on the 23d as the former degenerated into a trough. It moved across the lower Gulf of Alaska. At 0000 on the 24th the 994-mb LOW was near 53°N, 147°W, and the AKAISHI MARU reported 35-kn gales near 52°N, 149°W. Late on the 24th the storm curved northward to make a cyclonic loop. At 0000 on the 26th the ALEUTIAN DEVELOPER, at 54.1°N, 164.7°W, was hit by 50-kn northwesterly winds. The LOW was absorbed by another system on the 27th.

On the 28th, a LOW formed over the Kenai Peninsula and moved southward. At 0000 on the 29th, the 1000-mb LOW was near 51°N, 142°W. The AKADEMIK BERG battled 51-kn northwesterly winds at 55.4°N, 156°W, and the SERGEY YESENIN fought 60-kn winds at 54.1°N, 153.6°W. On the 30th a ship, at 49°N, 132°W, braved 45-kn winds with 20-ft waves. Another ship, at 47°N, 130°W, had 21-ft waves. The storm now had curved northward again and moved inland, about 0600, just north of Vancouver Island.

Tropical Cyclones, Western Pacific--Olga formed north of Yap Island on the 12th. She developed slowly while moving west-northwestward. On the 18th, just after Olga crossed the 15th parallel near 126°E, the AGANO MARU encountered 45-kn winds and 12-ft seas just south of her center. Olga did not reach typhoon strength until the 20th. She was headed for Luzon. The following day, generating 100-kn winds, Olga crashed ashore and moved across the island. Her strong winds and torrential rains (fig. 39) wreaked havoc for the next 4 days as Olga meandered northward just off the west coast of Luzon. Floods resulted in more than 50 deaths. A large stretch of dike collapsed, flooding several villages in the rice-rich plains north of Manila. Nearly 140,000 people had to evacuate to high ground, and at least 15,000 houses were under water in central Luzon. Some areas in Manila and surrounding provinces were reported under 6 ft of water. The Panamanian-registered freighter SENG HONG ran aground off Mindoro Island. The 18-man crew was rescued by a U.S. destroyer. By the 26th the weakening storm was accelerating northeastward and turning extratropical. She dissipated on the 27th near Okinawa.

While Olga was ravaging Luzon, Pamela was ripping over Guam with 130-kn winds and torrential rains. Pamela had formed near Truk on the 14th. She developed quickly and headed northwestward. Satawan Atoll in the Caroline Islands suffered under 50- to 60-kn winds on the 17th. By the 19th she had crossed the 10th parallel and was generating 100-kn plus winds. The following day she was a supertyphoon bearing down on Guam. Winds reached 120 kn with gusts to 165 kn destroying at least half of the buildings on the Island. It was the worst storm to hit Guam since typhoon Karen in November of 1962. Damages were estimated at more than $100 million. Three persons were known dead on Guam, and 10 people

Figure 39.--This aerial view is of the flooded central Luzon province of Pampanga. A major flood control dike collapsed and 50,000 persons were ordered evacuated. Wide World Photo.

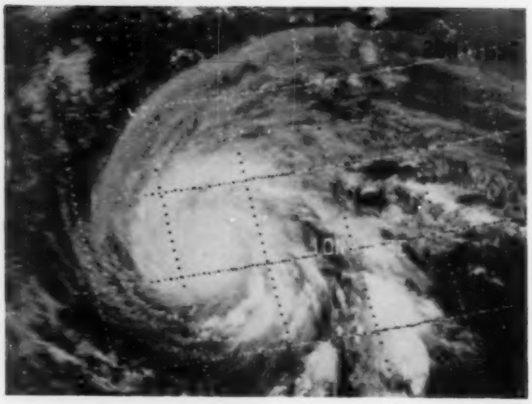

Figure 40.--Typhoon Pamela south of Guam on the 20th just prior to reaching supertyphoon strength.

Figure 41.--An example of the extensive damage resulting from Pamela's 100-kn winds which battered Guam for 18 hr. Wide World Photo.

Figure 42.--This building on Andersen Air Force Base, Guam, withstood the strong winds from Pamela better than the palm trees and panel truck which overturned. U.S. Air Force Photo.

died on Truk (figs. 40, 41, and 42). Three ships were blown aground at Guam. They were the 999-ton AKITSU MARU, the 997-ton PEACE OCEAN, and the 1,443-ton SLIDRE.

Pamela remained potent after leaving Guam. Winds near her center reached 135 kn on the 22d as the supertyphoon continued northwestward. The following day winds began to drop as the storm slowed and started turning northeastward. On the 28th Pamela was extratropical but still a severe storm. At 0000 the storm was near 39°N, 155°E, and the ASIA GOLD, at 40°N, 162°E, fought 50-kn winds. At 1200 the FUJISAN MARU was pounded by 25-ft seas and swells driven by a 40-kn wind near 39°N, 157°E, and the KAIWO MARU, near 36°N, 156°E, was rocked by 26-ft swells.

At 0000 on the 29th the 970-mb storm was at 46°N, 161°E. The JUNEAU MARU (47.5°N, 165°E) was on the eastern edge of the cold front with 45-kn gales and 33-ft swells. Seas and swells of 15 ft were common south of the center. A ship about 300 mi southeast of the center fought 26-ft waves at 0000 on the 30th. The storm was no longer significant by June 1.

Casualties--The 3,828-ton Korean vessel DONG SUE was abandoned by the crew in heavy weather on the 14th. She was listing heavily and taking on water and sank near 50.9°N, 120.8°E. The crew was rescued by the British SILVERFJORD. The 13,443-ton British motor vessel BARON MACLAY had a number of mooring lines parted and hull damage due to heavy swell. The 57,318-ton British motor vessel IRON SIRIUS was undergoing repairs at Port Kembla, Australia, on the 24th for alleged heavy weather damage.

SMOOTH LOG, JUNE 1976--There were vast differences between the climatological and actual storm tracks and pressure pattern this month. Climatology shows a primary storm path with a nearly constant northeasterly orientation from Japan to the northern Gulf of Alaska. Another primary path enters the Gulf of Alaska from a more southerly direction. A secondary path crosses the northern Kuril Islands and stretches eastward to the Andreanof Islands where it turns northeastward to the Kuskokwim Bay of Alaska.

This month the paths of the centers of the LOWs were very diffuse. There were also many short-lived LOWs (less than 30 hr) which do not show on the track chart. The path of most concentration stretched from northern Honshu eastward to the vicinity of 40°N, 175°W, where some dissipated while others loitered and turned northward toward the Bering Sea. One moved into the Gulf of Alaska. A few LOWs entered the Gulf of Alaska from the southwest. Two LOWs entered the Bering Sea from the west.

The pressure pattern was as different from climatology as the storm tracks. Normally, the primary Low is slightly north of Adak Island at 1010 mb. A 1011-mb Low is over the Alaska Range. The Pacific High at 1024 mb is near 33°N, 146°W, and bulges westward, being the most dominant feature. The High was still the dominant feature at 1027 mb near 37°N, 144°W, but it was more circular. Only a tongue of high pressure bulged westward between 20° and 30°N. The primary Low was 1011 mb centered near 41°N, 178°W. The pressure gradient over the western half of the ocean was very flat.

The anomaly chart was significant because of the positive centers over the northern ocean and the large negative center over the central ocean. A minus 4-mb center was near 38°N, 176°W. There were two plus 5-mb centers, one over Bristol Bay and the other to the southeast near 50°N, 150°W.

The upper-air pattern at 700 mb more closely resembled the climatological pattern. The primary Low was centered over the southern Bering Sea with two closed High cells centered near the center of each half of the ocean. A sharper-than-normal trough stretched southward along the 178°W meridian. Weak troughs paralleled both coasts.

Typhoons Ruby and Sally both formed late in the month. Hurricanes Annette and Bonny occurred over the eastern ocean.

Extratropical Cyclones--This was one of the LOWs that formed over Japan, near Nagoya, and tracked eastward to the central ocean. It was first detected on the 1200 chart of the 2d, on a front that paralleled the south coast of Honshu. At 0600 on the 3d, the SEIUN MARU, at 36°N, 146°E, found 45-kn northerly winds after the center passed to the east of her position. At 1200 the circulation was growing in size, but not in intensity.

On the 4th, a weak HIGH following the LOW started building and expanding. The LOW was being squeezed between the HIGH and a small HIGH to the east, and it gradually broke down to a frontal wave again. Late on the 6th, it could no longer be identified from the data.

There was only one really significant wind with this storm, but it was one of the higher ones for the month. The storm spent much of its life in a data-sparse area. It formed on the 2d, near 37°N, 171°E, and moved east-northeastward. On the 3d, it turned southeastward with a fairly large circulation and a central pressure of 998 mb. On the 4th, it developed into a cutoff LOW; by the 6th, the 1002-mb center had circled clockwise to 28°N, 169°W, prior to turning northward again. The winds were light with 25 to 30 kn the maximum, but, on the 8th, the KAIWO MARU had 16-ft swells on the west side near 36°N, 179°E. As the LOW moved northward, a front moved southeastward and was picked up in the circulation.

A HIGH to the north and another to the east were blocking any rapid movement of the LOW. As the cold front moved eastward against the HIGH, the MARITIME DOMINION was surprised by 55-kn southerly winds ahead of the front, at 0000 on the 9th, at 34.6°N, 163.5°W. The storm was moving due north as the blocking HIGH retreated into the Bering Sea and weakened fast. On the 11th, the LOW turned westward and disappeared on the 12th.

This LOW moved off the coast of China on the 4th and moved along the north coast of Japan on the 5th. At 1200 the KOLJUGEV reported 38-kn southerly winds off the Tsugaru Strait. At 0000 on the 6th, the LOW had split into two centers, one on each side of Honshu. The 1002-mb center off the east shore was the stronger and the one that survived. This

tightened the gradient on the east side of the LOW, and five vessels reported winds of 40 to 45 kn. The PACIFIC WIND, at 36°N, 146°E, reported the highest of 45 kn and 13-ft seas. Others were the KIKUWA MARU, POST CHARGER, and VAN TRIUMPH. The PRESIDENT FILLMORE (35.4°N, 144.4°E) fought 20-ft swells.

The LOW was moving on a northeasterly track along the Kuril Trench as the HIGH blocked easterly movement. At 0600 on the 7th, the ARISTEUS was southwest of the center near 40°N, 149°E, with 44-kn westerly winds. At 1800 the PRIVIV was bounced by 38-kn winds and 15-ft seas near 36°N, 160°E. There were no gale-force or higher winds reported on the 8th and 9th, and the LOW could no longer be identified by the 10th.

This frontal wave developed south of Tokyo on the 1200 chart of the 13th. By 0000 on the 15th, the LOW was 994 mb near 37°N, 150°E. The MARITIME DOMINION was nearing Japan as she approached the storm and encountered 46-kn gales. Six hours later, at 34.9°N, 152.9°E, she was fighting 56-kn southwesterly winds. At 0000 on the 16th, a ship with the call letters JAYT had 38-kn winds and 23-ft seas west of the center. Other ships were reporting 16- to 18-ft seas and swells. At 1200 the central pressure was 990 mb. The EXPORT CHALLENGER at 38.4°N, 158.3°E, found 40-kn westerlies, 20-ft seas, and 25-ft swells. On the 17th, the IRISH MAPLE and SHOWA MARU both labored with gales.

Between 0000 and 1200 on the 18th, the LOW filled 10 mb as it passed south of a LOW over the western Bering Sea. A ship near the other LOW had 45-kn winds. On the 19th, the LOW was gone.

On the 13th, a front stretched from Taiwan to 160°W, across nearly three quarters of the Pacific like a tightrope. There were four vibrations along the rope--frontal waves. One near 170°E was to amplify as it moved eastward, but not until the 15th. At 1200 it was near 44°N, 167°E, at 990 mb. At 1800 the PRESIDENT VAN BUREN, at 43.2°N, 161.6°W, encountered 38-kn winds. The winds around this storm were not especially high, but high swells were measured. At 0000 on the 16th, a ship whose code appeared to be the NOPAL LANE was swept by 41-ft swells near 42°N, 154°W. About 200 mi to the northwest, at 43.2°N, 158.9°W, the PRESIDENT VAN BUREN was now sailing with 20-ft seas and 25-ft swells on her stern. Far to the south, near 35°N, 170°W, the MARITIME RELIANCE suffered with 26-ft swells.

There were no more reports of extreme waves, but as the LOW stalled off Kodiak Island on the 18th, the JAMSONS encountered 40-kn gales from the west-southwest, south of the center. Before the day was over, so was the storm.

This closed cyclonic circulation was first analyzed on the 0000 chart of the 23d, around the point of occlusion of a frontal system. The CHIBA was about 200 mi east of the center, near 38°N, 174°E, with 40-kn gales. At 0000 on the 24th, the 1002-mb LOW was near 39°N, 177°E. The ALASKAN MAIL was at 38°N, 174°W, with 40-kn southeasterly gales. At 0000 on the 25th, there were three 40-kn reports north and west of the center by the AKADEMIK SHIRSHOV, SANKO-STAR, and SINCERE No. 5. At 0600 the DAIHO MARU (43°N, 179°E) was blown by 45-kn gales and tossed by 16-ft seas. By 0000 on the 26th, the 981-mb LOW had moved to 41°N, 175°W. North of the center, at 45°N, 179°E, the SHINYU MARU was sailing into 40-kn gales, 20-ft seas, and 30-ft swells. The DAIHO MARU, not far away at 43°N, 178°W, had 38 kn and 20-ft waves.

Late on the 26th, the LOW had three centers as one moved in from the west and another developed on the front. At 2300, the PRESIDENT FILLMORE at 45.8°N, 171.5°E, made a special observation indicating 13-ft seas and 30-ft swells. At 0000 on the 27th, the ALASKAN MAIL was sailing westward with 60-kn northerly winds. At 2100, the PRESIDENT FILLMORE was fighting 33-ft swells, which increased to 41 ft with 20-ft seas during the next 3 hr. At 0000 on the 28th, the MINETAMA MARU was 300 mi north of the LOW (984 mb) with 40-kn gales and 16-ft swells. Late on the 29th, the original LOW dissipated, and one of the new LOWs became the major circulation.

Tropical Cyclones, Eastern Pacific--June is usually considered the beginning of the eastern Pacific tropical cyclone season. Sure enough, the first depression was sighted on the 3d near 11°N, 95°W. Three days later, Annette was christened as the first tropical storm, and within 24 hr she became a hurricane. After an apparent initial indecision, Annette established a west-northwesterly track. She intensified rapidly. Maximum winds exceeded 100 kn from the 8th through the 11th. On the 9th at 1200, the 29,720-ton Norwegian bulkcarrier THORUNN encountered very rough swells in 35-kn winds nearly 200 mi northeast of the storm's center. Six hours later, a 60-kn wind came in from a ship 180 mi to the northeast of Annette's center. The hurricane reached a peak on the 10th when winds near her center were estimated at 120 kn with gusts to 135 kn. Early in the day, the KISO MARU, a Japanese fishing trawler, reported 35-kn winds some 100 mi south of the center. Late on the 11th, Annette passed within 100 mi of Socorro, which reported a 40-kn wind from the east. By the 14th, she was a weakening depression approaching 20°N, 115°W.

The beginning of hurricane Bonny turned up in the satellite photos on the 26th. She was just 180 mi south of Manzanillo. The suspense of whether she would head for land was quickly ended when she established a definite westward track. Bonny became a tropical storm late on the 26th; she was a hurricane 24 hr later by the time she crossed the 110th meridian near 17°N. At about this time a ship close to her center reported 50-kn winds in 6- to 8-ft seas. Her peak winds (65 kn) were only minimum hurricane intensity. Socorro reported only 20-kn winds as Bonny passed 80 mi to the south. By the 29th, she was a weakening depression as attested to by the 20-kn winds reported from near her center by the ATLANTIC STAR.

Tropical Cyclones, Western Pacific--Ruby and Sally formed in late June within 1 day of each other. They moved on parallel paths with Sally developing to the east. Ruby formed east of Samar in the Philippine Sea on the 23d. One day later, Sally was detected

(Continued on page 362.)

Principal Tracks of Centers of Cyclones at Sea Level, North Atlantic

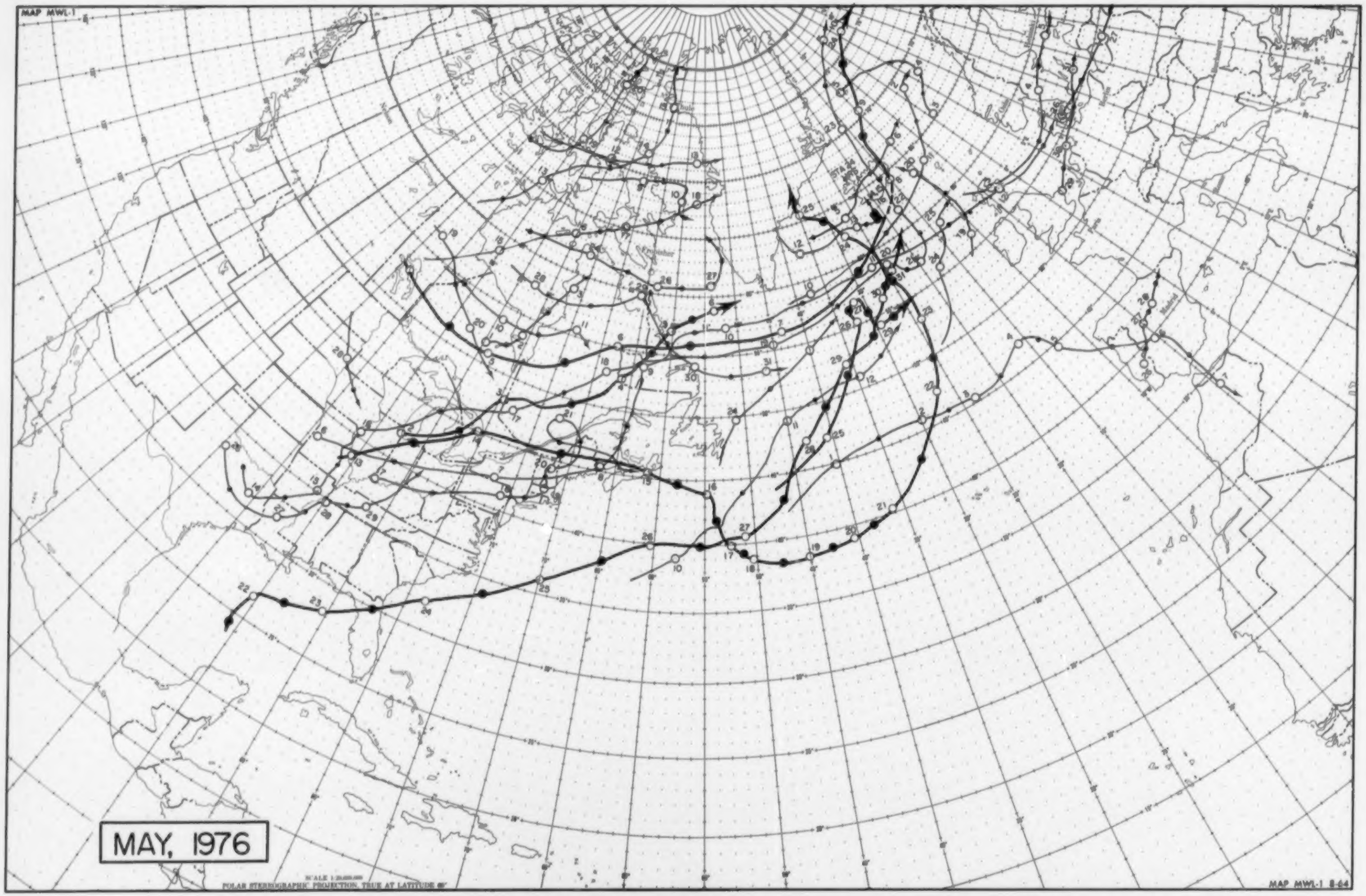

Figure 43. --Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

Principal Tracks of Centers of Cyclones at Sea Level, North Atlantic

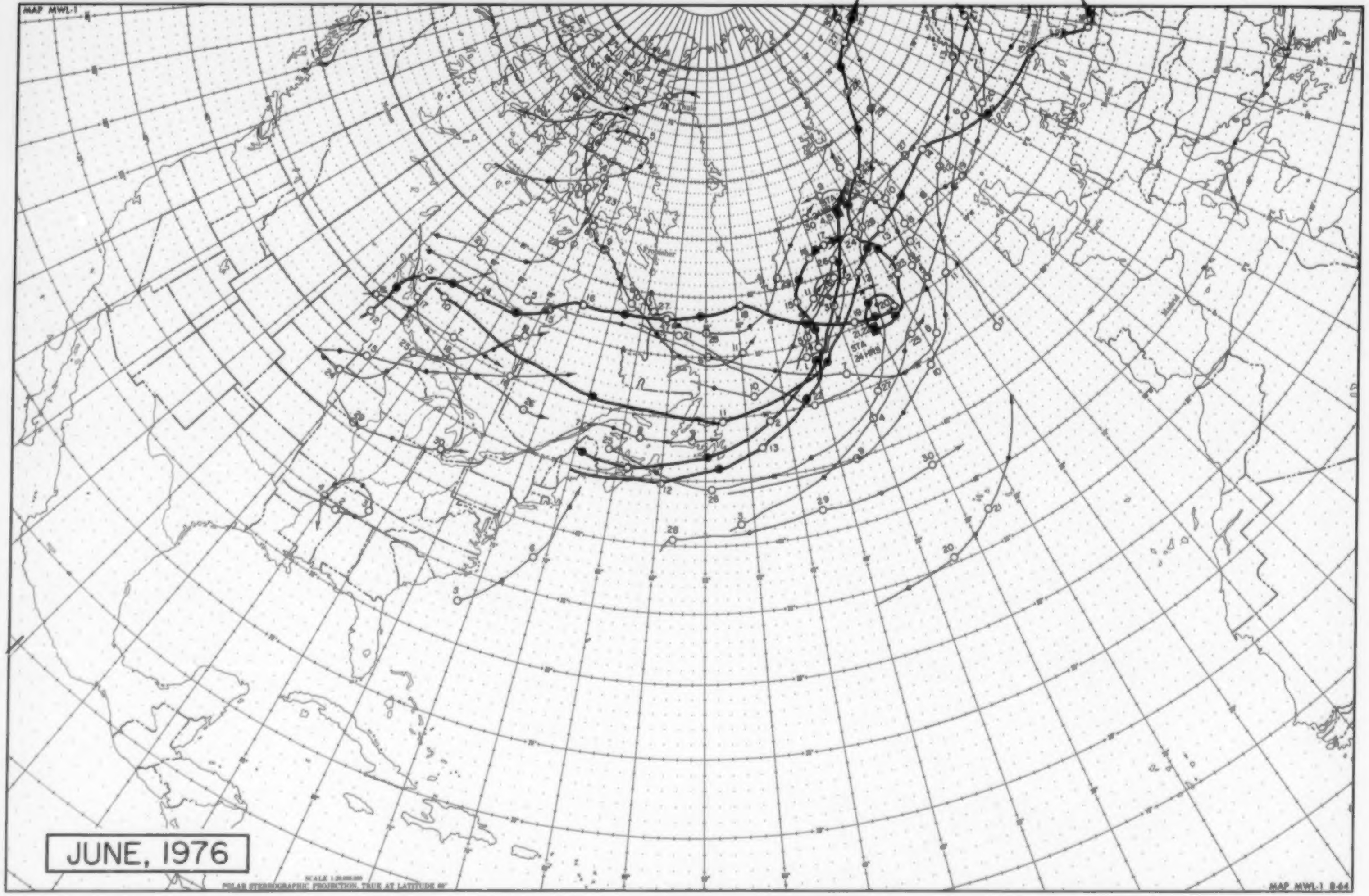

Figure 44. --Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

Principal Tracks of Centers of Cyclones at Sea Level, North Pacific

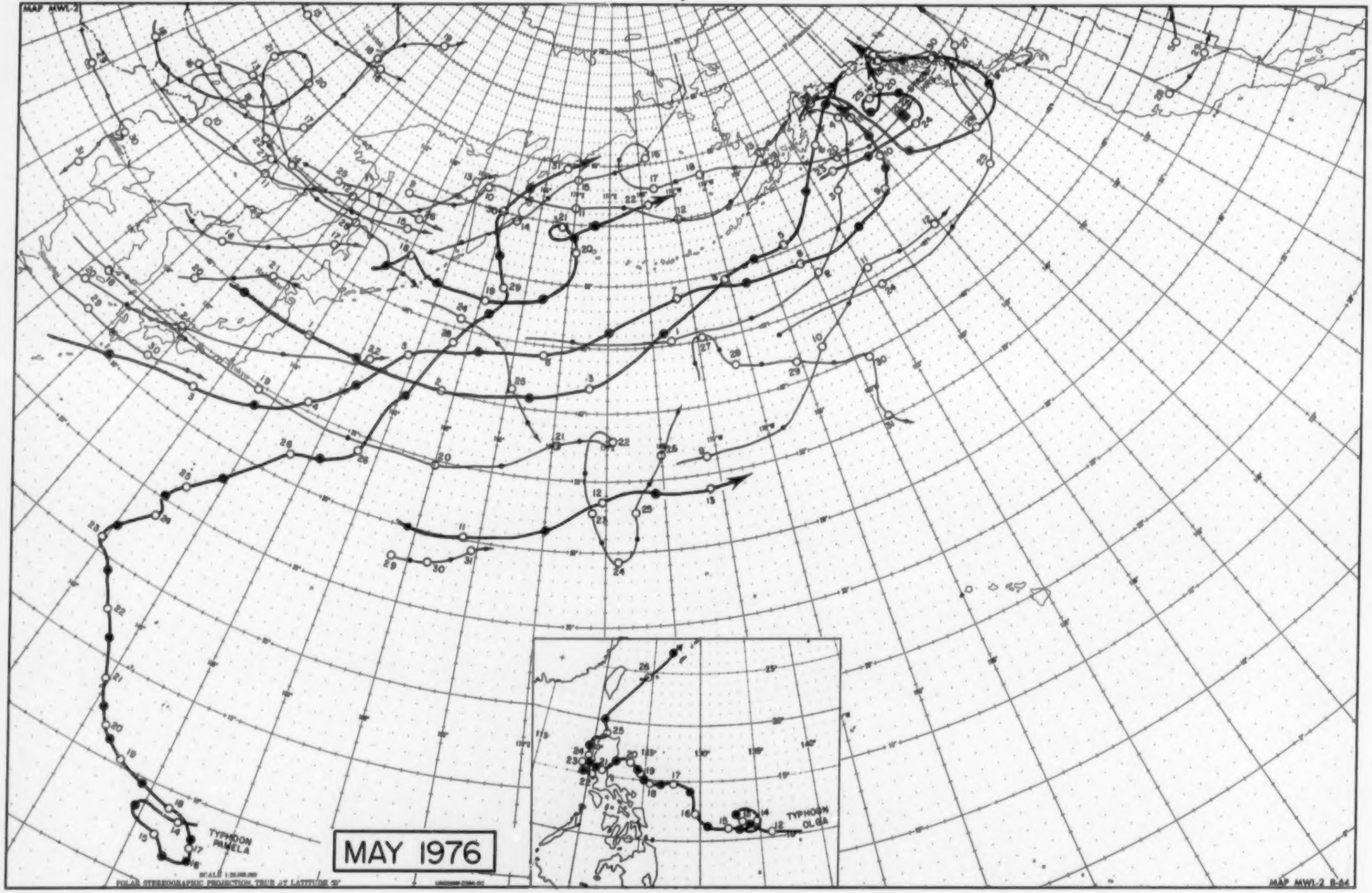

Figure 45. --Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

Principal Tracks of Centers of Cyclones at Sea Level, North Pacific

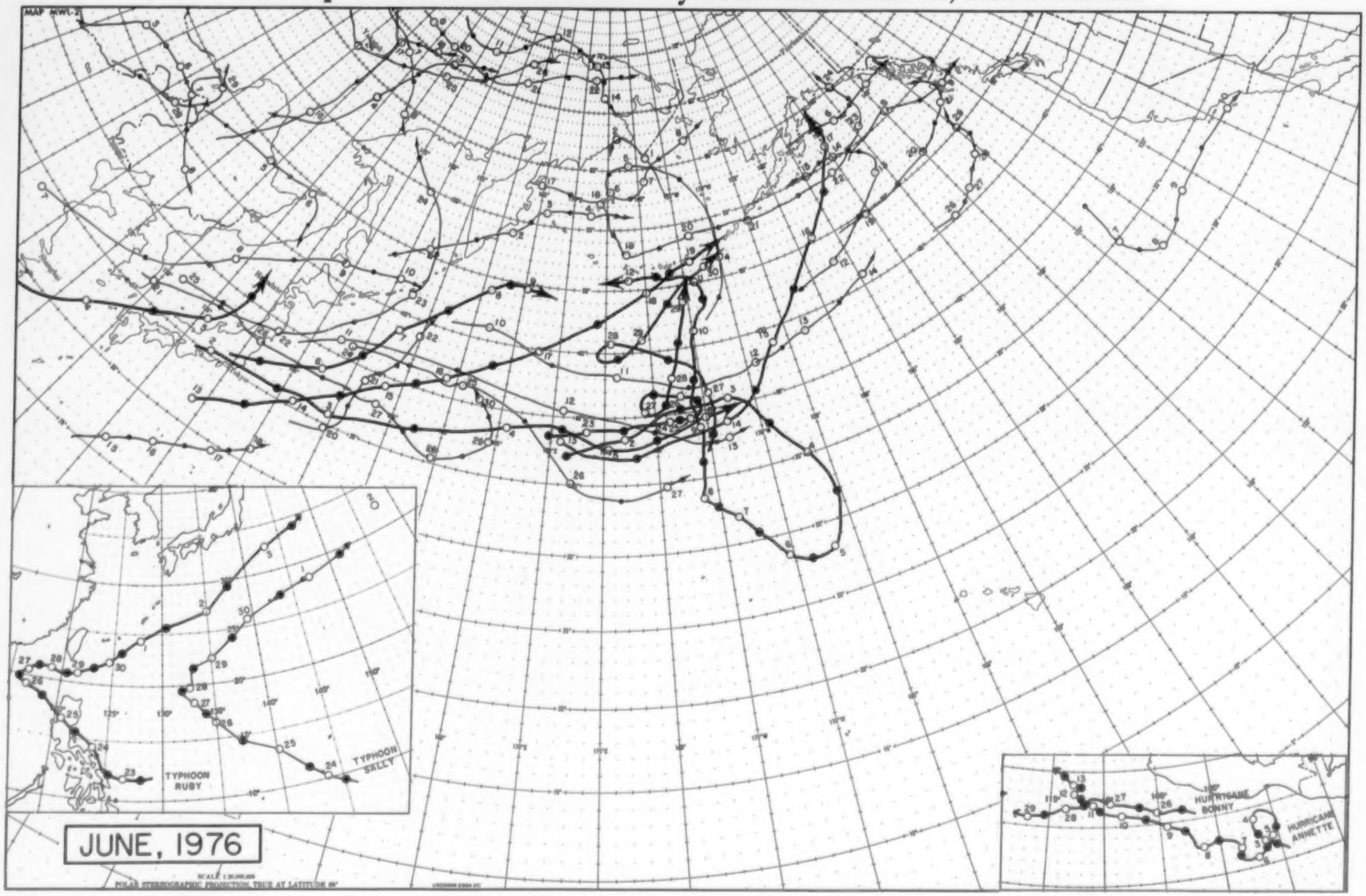

Figure 46. --Open circle indicates 1200 GMT position and closed circle 0000 GMT position. Square indicates stationary center. Cyclone tracks marked with a heavy line are described in the Smooth Log.

Table 5
U. S. Ocean Buoy Climatological Data
May and June 1976

JUNE — DATA SUMMARY — EB01
AVERAGE LATITUDE 35.0N — AVERAGE LONGITUDE 072.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	19.4	(05 15)	23.0	25.0	(30 18)	225	30
SEA TEMP (DEG C)	22.1	(11 09)	23.3	25.3	(28 12)	227	30
AIR-SEA TEMP (DEG C)	-02.9	(13 15)	-00.3	01.1	(09 21)	225	30
PRESSURE (MBAR)	1009.0	(12 12)	1019.4	1025.9	(23 15)	227	30

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 227

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		1.3	.4				1.8	9.5
NE		1.3	2.6	.4			4.4	14.6
E		4.0	3.1				7.0	11.0
SE		4.0	7.0				11.0	11.3
S		11.9	27.3	3.5			42.7	13.5
SW		5.3	23.3	.9			29.5	14.1
W		1.8	1.3				3.1	10.3
NW		.4					.4	7.0
CALM								
TOTAL		30.0	65.2	4.8			100.0	13.1

MAX WIND — SPEED: 28 KNOTS — DIRECTION: 200 DEG — DAY: 09 — HOUR: 00

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 177

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY	15.3	72.9	10.7	1.1					1.1M	3.0P	(09 03)

MAY — DATA SUMMARY — EB04
AVERAGE LATITUDE 26.0N — AVERAGE LONGITUDE 090.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	20.6	(29 09)	23.8	26.5	(09 21)	245	31
DEWPOINT TEMP (DEG C)	13.0	(04 00)	21.1	23.1	(14 03)	179	26
SEA TEMP (DEG C)	24.0	(05 15)	25.1	27.3	(12 00)	245	31
AIR-SEA TEMP (DEG C)	-04.4	(29 09)	-01.3	02.8	(09 21)	245	31
PRESSURE (MBAR)	1000.9	(22 21)	1013.2	1023.2	(04 15)	245	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 245

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	2.0	7.8	4.9	.4			15.1	9.1
NE	.4	2.9	5.7				9.0	11.3
E	1.6	9.0	7.8	.4			18.8	10.3
SE	2.9	8.2	15.1	.4			26.5	11.7
S	.4	6.1	2.4				9.0	9.3
SW	1.2	2.4	2.4				6.1	8.3
W	.4	3.7	1.6	.8			6.5	10.7
NW	1.2	1.2	5.3	.4			8.2	11.5
CALM	.8						.8	.0
TOTAL	11.0	41.2	45.3	2.4			100.0	10.4

MAX WIND — SPEED: 26 KNOTS — DIRECTION: 270 DEG — DAY: 22 — HOUR: 21

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 234

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY	51.7	44.9	3.4						.8M	2.5P	(14 15)

PRECIPITATION
NO. OF DAYS WITH PRECIP: 6 NO. OF DAYS WITH REPORTS/ COMPLETE: 30 PARTIAL: 1
NO. OF OBS WITH PAST OR PRESENT PRECIP: 9 NO. OF WEATHER OBS: 9

JUNE — DATA SUMMARY — EB04
AVERAGE LATITUDE 26.0N — AVERAGE LONGITUDE 090.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	23.9	(27 15)	26.2	29.5	(21 21)	236	30
DEWPOINT TEMP (DEG C)	19.6	(11 12)	22.7	25.2	(19 03)	236	30
SEA TEMP (DEG C)	25.4	(01 15)	26.4	27.2	(05 21)	68	9
AIR-SEA TEMP (DEG C)	-03.1	(08 21)	-01.0	01.6	(01 18)	67	9
PRESSURE (MBAR)	1009.4	(03 09)	1013.8	1019.6	(27 15)	237	30

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 237

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.4	.8	.4				1.7	6.8
NE	1.3	8.0	5.1				14.3	9.3
E	.8	19.8	24.9				45.6	10.4
SE	.4	16.0	9.3				25.7	9.9
S	1.3	3.0	1.7				5.9	7.1
SW	.8	1.7	.4				3.0	6.8
W	1.3	.8	.4				2.5	5.8
NW	.4						.4	2.0
CALM	.8						.8	.0
TOTAL	7.6	50.2	42.2				100.0	9.5

MAX WIND — SPEED: 18 KNOTS — DIRECTION: 130 DEG — DAY: 25 — HOUR: 06

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 230

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY	66.5	33.5							.7M	1.5P	(25 09)

PRECIPITATION
NO. OF DAYS WITH PRECIP: 14 NO. OF DAYS WITH REPORTS/ COMPLETE: 29 PARTIAL: 1
NO. OF OBS WITH PAST OR PRESENT PRECIP: 19 NO. OF WEATHER OBS: 19

MAY — DATA SUMMARY — EB15
AVERAGE LATITUDE 32.3N — AVERAGE LONGITUDE 075.3W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	18.8	(19 15)	21.2	23.9	(19 03)	244	31
SEA TEMP (DEG C)	21.3	(12 15)	22.1	23.6	(31 21)	243	31
AIR-SEA TEMP (DEG C)	-05.1	(19 15)	-01.0	01.6	(19 03)	243	31
PRESSURE (MBAR)	0994.5	(25 00)	1017.2	1027.9	(09 15)	244	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 244

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.4	1.6	2.0	.4	.4		4.9	15.2
NE		2.9	3.3	.4			6.6	12.1
E		1.2	8.6	2.5			12.3	15.8
SE		2.0	10.2	1.2			13.5	14.2
S		4.9	23.4	3.3			31.6	15.5
SW		1.2	16.4	2.0			19.7	16.7
W		2.0	5.7	.4			8.2	12.8
NW		.4	2.0	.4			3.3	17.5
CALM								
TOTAL	.4	16.4	71.7	11.1	.4		100.0	15.2

MAX WIND — SPEED: 35 KNOTS — DIRECTION: 340 DEG — DAY: 23 — HOUR: 00

JUNE — DATA SUMMARY — EB15
AVERAGE LATITUDE 32.3N — AVERAGE LONGITUDE 075.3W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	20.5	(07 21)	23.7	26.1	(26 21)	227	30
SEA TEMP (DEG C)	23.1	(01 09)	24.7	27.0	(26 00)	228	30
AIR-SEA TEMP (DEG C)	-03.8	(07 21)	-01.1	01.3	(12 21)	228	30
PRESSURE (MBAR)	1009.4	(08 09)	1018.6	1024.7	(23 15)	227	30

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 226

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	1.3	.9					2.2	3.7
NE		1.3	.4				1.8	7.8
E	.4	1.3	8.0	.4			10.2	14.4
SE	.4	8.0	11.1	.4			19.9	11.2
S	3.1	12.4	29.6	1.3			46.5	12.4
SW	2.7	6.2	5.8				14.6	9.2
W	.9	3.1					4.0	5.1
NW	.9						.9	2.0
CALM								
TOTAL	9.7	33.2	54.9	2.2			100.0	11.3

MAX WIND — SPEED: 28 KNOTS — DIRECTION: 170 DEG — DAY: 08 — HOUR: 06

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 165

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY	24.8	68.5	6.7						1.0M	2.0P	(30 18)

MAY — DATA SUMMARY — EB16
AVERAGE LATITUDE 42.5N — AVERAGE LONGITUDE 130.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	08.5	(16 15)	10.3	13.2	(13 00)	172	22
SEA TEMP (DEG C)	08.8	(03 15)	11.2	12.6	(24 00)	241	31
AIR-SEA TEMP (DEG C)	-02.8	(16 15)	-00.6	00.8	(10 18)	171	22
PRESSURE (MBAR)	1011.0	(27 00)	1023.3	1033.2	(14 18)	233	31

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 239

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.8	4.2	17.2				22.2	14.0
NE		1.3	.4				1.7	8.0
E	.8	.4					1.3	3.7
SE	.4	1.3					1.7	5.3
S	3.3	5.4	5.0				13.6	8.3
SW	.4	6.7	9.2	1.3			17.6	11.8
W	.4	9.2	12.1	.4			22.2	12.1
NW	.4	5.0	11.7	3.3			20.5	14.9
CALM								
TOTAL	5.9	35.5	55.6	5.0			100.0	12.4

MAX WIND — SPEED: 26 KNOTS — DIRECTION: 300 DEG — DAY: 16 — HOUR: 15

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) — NO. OF WAVE OBS: 172

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY	22.7	56.4	20.9						1.3M	2.3P	(16 21)

JUNE — DATA SUMMARY — EB16
AVERAGE LATITUDE 42.5N — AVERAGE LONGITUDE 130.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
SEA TEMP (DEG C)	12.0	(03 15)	13.1	14.3	(29 00)	238	30
PRESSURE (MBAR)	1010.4	(20 12)	1022.1	1032.6	(23 21)	239	30

WIND - % FREQUENCIES, MEANS AND EXTREMES — NO. OF OBS: 237

DIR	<4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.8	13.9	28.7				43.5	12.0
NE	.8	5.1	4.6				10.5	8.0
E	.8	1.7					2.5	5.2
SE	.8	.8					1.7	3.5
S	.4	3.4					3.8	6.3
SW	.4	[illegible]	1.7				5.1	9.6
W	.4	4.2	11.0	1.3			17.3	13.7
NW	.4	5.5	8.9				14.8	11.3
CALM	.8						.8	.0
TOTAL	6.8	37.1	54.9	1.3			100.0	11.1

MAX WIND — SPEED: 22 KNOTS — DIRECTION: 280 DEG — DAY: 30 — HOUR: 03

MAY DATA SUMMARY E834

AVERAGE LATITUDE 40.1N AVERAGE LONGITUDE 073.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	06.0	(19 12)	12.2	17.1	(20 21)	235	31
SEA TEMP (DEG C)	08.8	(02 12)	11.5	15.7	(28 21)	235	31
AIR-SEA TEMP (DEG C)	-05.6	(19 12)	00.7	03.5	(21 00)	234	31
PRESSURE (MBAR)	0995.4	(19 06)	1014.7	1025.9	(17 15)	234	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.4	1.7	2.2				4.3	9.2
NE		2.6	1.7				4.3	10.2
E		2.6	2.6				5.2	9.6
SE	.4	3.5	1.7	.4			6.1	10.0
S	.9	5.7	17.0	.4			23.9	12.3
SW	1.3	13.9	14.8	.4			30.4	11.0
W	1.7	7.8	3.5	3.5			16.5	12.9
NW	.9	1.7	5.2	1.3			9.1	14.0
CALM								
TOTAL	5.7	39.6	48.7	6.1			100.0	11.7

NO. OF OBS: 230

MAX WIND
SPEED: 29 KNOTS
DIRECTION: 280 DEG
DAY: 19
HOUR: 12

MAY DATA SUMMARY E841

AVERAGE LATITUDE 38.7N AVERAGE LONGITUDE 073.6W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	07.9	(19 09)	13.4	18.7	(17 03)	240	31
SEA TEMP (DEG C)	09.7	(02 00)	12.6	16.2	(28 21)	239	31
AIR-SEA TEMP (DEG C)	-05.5	(19 09)	00.8	03.4	(02 03)	239	31
PRESSURE (MBAR)	0999.0	(19 00)	1015.8	1027.2	(05 12)	239	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.8	1.7	.4	.4			3.4	9.3
NE		3.4	5.5				8.9	12.4
E		3.4	1.7				5.1	9.7
SE	.4	5.5	5.1	.4			11.4	10.1
S	.9	8.9	22.0	.4			32.2	12.3
SW	1.3	9.7	6.8	.4			18.2	11.0
W	.4	6.4	4.7	2.5			14.0	13.8
NW		1.7	3.0	1.7			6.4	15.3
CALM	.4						.4	.0
TOTAL	4.2	40.7	49.2	5.9			100.0	11.9

NO. OF OBS: 236

MAX WIND
SPEED: 30 KNOTS
DIRECTION: 270 DEG
DAY: 19
HOUR: 12

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 243

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY	33.7	49.8	14.8	1.6					1.1M	3.0M	(19 15)

MAY DATA SUMMARY E861

AVERAGE LATITUDE 28.5N AVERAGE LONGITUDE 090.9W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	18.7	(08 03)	23.1	26.4	(31 21)	202	31
PRESSURE (MBAR)	1005.5	(22 21)	1015.2	1023.0	(04 18)	201	31

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		2.6	3.6	2.6			8.7	16.3
NE		3.6	7.1	1.0			11.7	13.9
E		3.1	13.3				16.3	12.8
SE		5.1	9.7				14.8	12.2
S	.5	4.6	7.1				12.2	12.0
SW	.5	5.1	3.1				8.7	8.7
W	.5	9.2	8.7				18.4	10.9
NW		3.6	5.6				9.2	12.1
CALM								
TOTAL	1.5	36.7	58.2	3.6			100.0	12.3

NO. OF OBS: 196

MAX WIND
SPEED: 32 KNOTS
DIRECTION: 020 DEG
DAY: 22
HOUR: 15

JUNE DATA SUMMARY E834

AVERAGE LATITUDE 40.1N AVERAGE LONGITUDE 073.0W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	12.1	(02 12)	17.0	22.8	(24 21)	236	30
SEA TEMP (DEG C)	13.1	(03 09)	17.2	22.0	(28 18)	239	30
AIR-SEA TEMP (DEG C)	-01.7	(13 06)	00.7	03.1	(12 06)	238	30
PRESSURE (MBAR)	1003.8	(12 06)	1016.6	1029.9	(05 15)	236	30

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N		1.3					1.3	8.3
NE		5.5	3.8	1.3			10.6	11.5
E	.4	1.7	2.5				4.7	11.3
SE	.8	3.0	.8				4.7	7.7
S	.4	9.3	16.1				25.8	11.1
SW	.4	15.3	27.3				43.2	11.7
W		3.4	.8				4.2	8.1
NW	.4	4.2	.8				5.5	7.0
CALM								
TOTAL	2.5	43.6	52.5	1.3			100.0	10.9

NO. OF OBS: 236

MAX WIND
SPEED: 26 KNOTS
DIRECTION: 090 DEG
DAY: 02
HOUR: 12

JUNE DATA SUMMARY E841

AVERAGE LATITUDE 38.7N AVERAGE LONGITUDE 073.6W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	12.3	(03 00)	18.1	23.7	(28 03)	238	30
SEA TEMP (DEG C)	13.2	(06 09)	17.2	22.8	(20 18)	238	30
AIR-SEA TEMP (DEG C)	-01.6	(02 21)	00.9	04.0	(02 06)	238	30
PRESSURE (MBAR)	1006.5	(12 09)	1017.8	1028.3	(09 15)	238	30

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	.4	.4	2.1				3.0	11.9
NE		.4	11.0	1.3			12.7	16.0
E		1.3	3.8				5.1	12.9
SE		5.5	3.8				9.3	9.8
S	1.3	11.0	25.4				37.7	11.9
SW	.4	7.6	15.7				23.7	11.3
W		5.1	1.7				6.8	9.1
NW	.4	1.3					1.7	5.3
CALM								
TOTAL	2.5	32.6	63.6	1.3			100.0	12.0

NO. OF OBS: 236

MAX WIND
SPEED: 23 KNOTS
DIRECTION: 030 DEG
DAY: 02
HOUR: 18

WAVES - % FREQUENCIES, MEAN AND EXTREME (METERS) NO. OF WAVE OBS: 240

HEIGHT (M)	<1	1-1.5	2-2.5	3-3.5	4-5.5	6-7.5	8-9.5	>9.5	MEAN	MAX	(DA HR)
% FREQUENCY	23.3	67.9	7.9	.8					1.1M	3.0M	(03 00)

JUNE DATA SUMMARY E861

AVERAGE LATITUDE 28.9N AVERAGE LONGITUDE 090.9W

MEANS AND EXTREMES	MIN	(DA HR)	MEAN	MAX	(DA HR)	NO. OF OBS	DAYS WITH DATA
AIR TEMP (DEG C)	22.8	(07 15)	28.0	30.7	(10 21)	130	22
PRESSURE (MBAR)	1011.6	(03 00)	1015.2	1018.2	(13 15)	137	22

WIND - % FREQUENCIES, MEANS AND EXTREMES

DIR	SPEED (KNOTS) <4	4-10	11-21	22-33	34-47	>47	TOTAL %	MEAN SPEED (KNOTS)
N	1.5	1.5					3.1	4.3
NE	.8	3.1	5.4				9.2	10.6
E	2.3	7.7	19.2	.8			30.0	12.2
SE	2.3	8.5	10.8				21.5	9.8
S	3.8	7.7	6.9				18.5	8.1
SW	3.1	4.6					7.7	4.1
W	3.1	1.5					4.6	2.7
NW	2.3	1.5					3.8	3.2
CALM	1.5						1.5	.0
TOTAL	20.8	34.2	42.3	.8			100.0	8.9

NO. OF OBS: 130

MAX WIND
SPEED: 22 KNOTS
DIRECTION: 090 DEG
DAY: 07
HOUR: 03

Table 6
Selected Gale and Wave Observations, North Atlantic
May and June 1976

Vessel	Nationality	Date	Position of Ship: Lat. deg.	Position of Ship: Long. deg.	Time GMT	Wind: Dir. 10°	Wind: Speed kt.	Visibility n. mi.	Present Weather code	Pressure mb.	Temperature °C: Air	Temperature °C: Sea	Sea Waves◆: Period sec.	Sea Waves◆: Height ft.	Swell Waves: Dir. 10°	Swell Waves: Period sec.*	Swell Waves: Height ft.
NORTH ATLANTIC OCEAN		MAY															
PRES EISENHOWER	AMERICAN	2	40.4 N	67.3 W	12	09	35	5 NM	02	1015.3	18.4	19.4	8	14.5			
BALTIMORE TRADER	AMERICAN	2	36.8 N	73.4 W	06	18	40	2 NM	15	1000.9	20.0				18	X	14.5
DORIC	PANAMANIAN	2	37.4 N	70.2 W	12	18	35	5 NM	02	1012.0	21.0	20.0	6	10			
TENADORES	HONDURAN	3	41.3 N	26.7 W	18	31	45	10 NM	02	1014.9	13.5	14.3	6	6.5	31	8	18
SEALAND ECONOMY	AMERICAN	5	46.3 N	17.4 W	18	36	35	10 NM	01	1014.2	10.6	12.8	4	6.5	36	7	13
SOLON TURMAN	AMERICAN	7	30.8 N	01.8 W	18	07	M 40	5 NM	02	1008.4	16.7	16.2			07	6	11.5
WESER ORE	LIBERIAN	11	41.8 N	10.5 W	06	02	36	10 NM	03	1022.7	11.5	14.6	9	18			
EXXON PHILADELPHIA	AMERICAN	15	25.4 N	85.3 W	00	14	35	.5 NM	65	1010.3	26.7	26.5	6	10			
SEALAND RESOURCE	AMERICAN	16	41.6 N	36.2 W	18	31	35	5 NM	02	1007.0	8.3	16.7	3	6.5	31	8	8
SNOW FLAKE	SWEDISH	16	48.7 N	13.0 W	06	22	38	2 NM		1010.0	13.0		7	11.5			
AMER LEGACY	AMERICAN	16	48.9 N	10.3 W	18	20	35	5 NM	02	1010.0	13.3	11.7	4	6.5	23	8	10
SEALAND RESOURCE	AMERICAN	17	41.2 N	32.1 W	00	30	35	5 NM	02	1004.5	11.0	15.0	3	6.5	30	7	10
AUSTRAL PATRIOT	AMERICAN	17	35.7 N	60.7 W	12	32	35	> 25 NM	03	1016.5	18.6	21.1	5	10	32	11	10
AMER LEGACY	AMERICAN	17	48.6 N	12.6 W	00	20	35	5 NM	18	1006.5	10.6	12.3	4	5	20	7	11.5
BERGLJOT	NORWEGIAN	18	30.9 N	11.3 W	06	01	M 38	10 NM	03	1022.5	16.5	17.0	8	11.5			
EAGLE CHARGER	AMERICAN	18	36.3 N	42.1 W	12	19	40	10 NM	02	1016.3	20.5	18.6	5	10			
EXXON LEXINGTON	AMERICAN	19	35.9 N	74.7 W	00	27	40	10 NM	02	1002.7	20.7	26.7	8	10			
MT MITCHELL	AMERICAN	19	38.7 N	74.2 W	18	27	M 35	10 NM	02	1005.8	11.1	12.7			27	6	6.5
BALTIMORE	AMERICAN	19	34.2 N	75.3 W	06	34	35	5 NM	25	1009.5	14.5	27.8	10	8			
HESS VOYAGER	AMERICAN	19	35.3 N	71.6 W	12	30	M 38	10 NM	01	1009.8	17.7	20.0	5	8			
JACKSONVILLE	AMERICAN	19	35.5 N	72.4 W	12	28	40	10 NM	01	1010.7	17.4	23.3	3	6.5	28	9	10
MOBIL FUEL	AMERICAN	19	39.8 N	70.1 W	12	20	35	5 NM	05	997.6	11.7	11.2	14	16.5			
EAGLE CHARGER	AMERICAN	19	36.3 N	36.7 W	06	17	40	10 NM	02	1020.0	16.8	18.6	5	8			
EXXON NEW ORLEANS	AMERICAN	19	33.5 N	74.7 W	00	19	35	5 NM	92	1003.4	23.3	22.7			19	< 6	11.5
BORINQUEN	AMERICAN	20	39.0 N	74.0 W	12	24	40	10 NM	02	1009.8	13.4	10.7	5	10			
MOBIL POWER	AMERICAN	21	26.4 N	87.7 W	18	14	35	5 NM	62	1012.9	23.3	25.6			14	12	19.5
EXPORT PATRIOT	AMERICAN	21	47.6 N	30.0 W	18	04	45	2 NM	07	1002.4	10.0	13.9	4	6.5	04	9	8
EXXON FLORENCE	AMERICAN	22	26.3 N	87.5 W	18	23	35	10 NM	03	1007.1	26.6	25.6	2	5	23	< 6	10
SOLON TURMAN	AMERICAN	22	28.4 N	90.4 W	18	07	M 40	5 NM	15	1003.8	23.3	23.9	3	5	07	7	19.5
AMER LEGEND	AMERICAN	22	47.9 N	27.7 W	12	02	M 42	1 NM	62	992.0	10.0	11.7	6	13	02	9	16.5
JACKSONVILLE	AMERICAN	22	36.4 N	73.4 W	00	24	35	10 NM	02	1009.6	24.2	22.2	5	6.5			
EXPORT PATRIOT	AMERICAN	22	48.4 N	24.5 W	06	18	50	2 NM		1000.0	13.4	12.8			18	9	8
WESER ORE	LIBERIAN	23	44.6 N	21.0 W	18	27	40	5 NM	01	1008.3	12.0	14.0	8	19.5			
SNOWDRIFT	SWEDISH	23	46.2 N	24.2 W	06	25	40	2 NM	80	1000.0	10.2		10	13			
LIGHTNING	AMERICAN	23	47.6 N	21.9 W	11	19	40	5 NM	25	992.2	16.0	13.3	4	10	21	7	18
EXXON HUNTINGTON	AMERICAN	24	32.0 N	76.3 W	12	20	35	10 NM	01	997.6	25.0	23.3	8	14.5			
SNOWDRIFT	SWEDISH	24	48.4 N	15.0 W	00	20	35	2 NM	16	1004.5	12.0						
OCEANIC	PANAMANIAN	24	30.4 N	73.8 W	12	22	M 36	10 NM	13	1002.4	22.8	24.4	8	6.5			
WESER ORE	LIBERIAN	24	44.2 N	22.4 W	00	30	35	2 NM	50	1018.0	12.8	14.0	8	19.5			
AMER COURIER	AMERICAN	24	59.0 N	10.2 W	12	16	45	2 NM		1005.8	12.8	10.0			16	7	10
CARBIDE TEXAS CITY	AMERICAN	24	31.0 N	80.0 W	12	23	35	10 NM	20	997.0	22.2	25.0			22	8	8
MOBIL POWER	AMERICAN	24	36.9 N	72.9 W	18	04	35	5 NM	14	1006.4	15.6	25.0	12	16	06	10	21
LIGHTNING	AMERICAN	24	46.8 N	26.0 W	00	29	35	10 NM	02	1015.2	11.7	13.3	4	6.5	30	< 6	11.5
WESER ORE	LIBERIAN	25	40.6 N	34.2 W	18	20	37	5 NM	02	1017.9	17.5	16.8	6	10			
STONEWALL JACKSON	AMERICAN	26	37.9 N	58.2 W	12	21	M 36	5 NM	01	1010.9	21.2	19.4	4	10			
WESER ORE	LIBERIAN	26	40.1 N	35.7 W	00	22	38	2 NM	61	1013.5	17.0	17.0	10	11.5			
AMER COURIER	AMERICAN	26	51.1 N	29.7 W	12	23	35	5 NM	16	995.7	11.2	8.8	7	10			
AMER ALLIANCE	AMERICAN	26	41.6 N	51.0 W	12	09	35	5 NM	60	1007.5	11.5	14.4	8	14.5			
AMER RANGER	AMERICAN	27	41.6 N	47.1 W	18	25	38	10 NM	02	1007.5	18.8	16.7	5	8	25	8	14.5
SEALAND RESOURCE	AMERICAN	28	45.3 N	35.4 W	18	21	42	5 NM	61	999.9	15.0	11.7	4	13	23	7	18
AMER RANGER	AMERICAN	28	41.3 N	50.1 W	00	25	38	10 NM	02	1002.0	19.4	16.7	5	8	25	8	14.5
AMER COURIER	AMERICAN	28	41.4 N	45.6 W	12	27	35	10 NM	01	1007.5	15.0	16.7	5	10			
MOBIL AERO	AMERICAN	28	33.0 N	76.9 W	18	08	40	5 NM	80	1019.6	22.2	25.0	4	6.5	08	8	13
SEALAND RESOURCE	AMERICAN	29	44.9 N	37.4 W	00	26	45	5 NM	02	1004.0	12.7	11.7	4	10	26	9	23
DEL RIO	AMERICAN	30	20.3 N	71.5 W	06	10	35	10 NM	15	1014.0	26.7	26.7	3	6.5			
ROBERT TOOMBS	AMERICAN	31	38.9 N	57.9 W	18	25	35	5 NM	81	1016.8	23.9	19.4	5	13	25	6	16.5
AMER ARCHER	AMERICAN	31	43.6 N	48.0 W	23	24	40	50 YD	21	1007.0	11.1	6.7			24	9	13
GREAT LAKES VESSELS																	
ENDERS M VOORHEES	AMERICAN	3	45.1 N	85.8 W	00	33	M 35	5 NM	02		4.0	3.0	3	5			
J C HAUTHE	AMERICAN	3	47.0 N	85.8 W	18	33	M 39	10 NM	05		3.0	3.0	6	14.5			
CHAMPLAIN	AMERICAN	3	44.7 N	83.1 W	06	30	M 38	10 NM	21		3.0	8.0	2	5			
ELTON HOYT II	AMERICAN	3	45.0 N	86.6 W	00	33	M 38	10 NM	85		1.0	2.0	7	8			
ELTON HOYT II	AMERICAN	5	43.6 N	85.3 W	06	22	M 36	> 25 NM	05		8.0	2.8	5	5			
CLIFFS VICTORY	AMERICAN	10	46.8 N	83.2 W	06	20	M 35	> 25 NM	00		11.0	2.0	3	3			
NORTH ATLANTIC OCEAN		JUNE															
AMER CHAMPION	AMERICAN	1	50.9 N	28.9 W	18	22	45	1 NM	80	1004.7	12.2	12.8	7	16.5	22	8	41
AMER CHAMPION	AMERICAN	2	47.3 N	34.5 W	12	25	40	10 NM	02	1018.3	15.6	13.4	5	10	24	8	32.5
SEALAND MARKET	AMERICAN	3	45.5 N	17.2 W	00	31	35	10 NM	00	1030.0	10.4	11.2	6	10			
AMER CHAMPION	AMERICAN	3	44.2 N	41.0 W	08	23	35	.5 NM		1015.5	14.5	15.6	5	10	23	8	24.5
GULFQUEEN	AMERICAN	4	39.4 N	64.0 W	18	08	35	2 NM	83	1021.3	16.5	15.0	7	13			
JACKSONVILLE	AMERICAN	5	35.3 N	74.0 W	00	05	35	5 NM	62	1020.5	22.0	27.8	7	10			
HESS VOYAGER	AMERICAN	5	36.9 N	72.2 W	12	04	35	5 NM	15	1020.7	19.0	14.5			04	7	8
CARBIDE TEXAS CITY	AMERICAN	5	37.1 N	74.6 W	23	05	35	10 NM	02	1022.7	14.4	15.6	5	16.5			
AFRICAN MERCURY	AMERICAN	5	37.9 N	69.8 W	12	05	35	5 NM	03	1022.0	18.9	20.0	6	8			
BALTIMORE	AMERICAN	5	34.4 N	76.3 W	06	01	35	5 NM	02	1020.0	17.8	22.8	8	6.5	02	12	8
DORIC	PANAMANIAN	6	37.4 N	70.7 W	12	18	M 35	10 NM	02	1015.5	23.0	21.0	6	6.5			
SEALAND RESOURCE	AMERICAN	6	38.4 N	67.2 W	00	05	40	1 NM	33	1019.8	20.0	20.0	3	13			
STAGHOUND	AMERICAN	7	36.2 N	03.2 W	06	07	35	10 NM	01	1008.8	18.9	18.9	4	8			
EXPORT FREEDOM	AMERICAN	8	41.9 N	35.5 W	18	25	35	5 NM	25	1007.5	14.5	17.2	7	8			
AMER ALLIANCE	AMERICAN	8	45.9 N	28.3 W	06	27	35	5 NM	15	997.8	12.3	10.7	4	5	29	7	10
EXXON NEW ORLEANS	AMERICAN	12	38.7 N	70.7 W	18	01	35	5 NM	05	1011.5	17.5	18.8	4	6.5			
YOUNG AMERICA	AMERICAN	13	41.9 N	56.5 W	12	32	40	5 NM	02	1011.9	10.6	12.3	5	16.5	32	7	23
MAI SILVANA	ITALIAN	13	39.5 N	57.9 W	12	32	36	5 NM	07	1020.0	16.0	20.0	XX	11.5			
STOLT LLANDAFF	BRITISH	13	42.8 N	60.7 W	06	31	35	5 NM	01	1010.8	8.0	10.0	4	8	35	< 6	18
SEALAND GALLOWAY	AMERICAN	13	41.5 N	36.3 W	06	28	35	5 NM	02	1002.0	10.6	16.2	8	16.5			
SHERMAN	AMERICAN	13	37.2 N	47.9 W	12	22	M 42	5 NM	01	1011.2	22.3	21.1	7	8			
SHELDON LYKES	AMERICAN	14	33.2 N	61.1 W	00	08	M 38	5 NM	07	1020.7	21.7	25.0					
AMER LEGACY	AMERICAN	15	47.3 N	30.4 W	18	26	45	10 NM	02	1020.2	16.2	14.4	3	6.5	26	11	29.5
AMER LEGACY	AMERICAN	16	46.2 N	39.4 W	18	23	35	5 NM	02	1010.8	15.0	13.3			23	7	10
MEADOWBROOK	AMERICAN	19	15.5 N	76.8 W	12	08	40	5 NM	02	1011.5	26.7	27.2	4	6.5	09	8	13
ORE MERCURY	LIBERIAN	23	52.2 N	21.9 W	18	21	50	2 NM		988.0	14.5	11.7			21	9	13.5
GLOMAR CHALLENGER	AMERICAN	28	56.0 N	23.2 W	06	20	M 35	.25 NM	80	1005.8	10.0	10.6	7	10			
GREAT LAKES VESSELS																	
ENDERS M VOORHEES	AMERICAN	24	47.1 N	91.0 W	18	24	M 45	2 NM	62		12.0	8.0	3	5			

◆ Direction for sea waves same as wind direction
X Direction or period of waves indeterminate
M Measured wind

NOTE: The observations are selected from those with winds ≥ 35 kn or waves ≥ 25 ft from May through August (≥ 41 kn or ≥ 33 ft, September through April). In cases where a ship reported more than one observation a day with such values, the one with the highest wind speed was selected.

Table 7
Selected Gale and Wave Observations, North Pacific
May and June 1976

Vessel	Nationality	Date	Position of Ship: Lat. deg.	Position of Ship: Long. deg.	Time GMT	Wind: Dir. 10°	Wind: Speed kt.	Visibility n. mi.	Present Weather code	Pressure mb.	Temperature °C: Air	Temperature °C: Sea	Sea Waves: Period sec.	Sea Waves: Height ft.	Swell Waves: Dir. 10°	Swell Waves: Period sec.	Swell Waves: Height ft.
NORTH PACIFIC OCEAN		MAY															
OYVI OCEANIC	NORWEGIAN	1	42.7 N	168.2 W	12	16	36	2 NM	50	991.0	9.0	8.0			16	X	13
BREWSTER	PANAMANIAN	1	40.2 N	175.4 E	12	27	M 35	2 NM		999.8	8.0	12.0			27	8	14.5
SHUNWIND	LIBERIAN	1	54.8 N	178.9 W	00	34	M 42	.5 NM	45	1000.5	2.0	2.0	6	6.5	33	8	13
ZIM NEW YORK	GERMAN	2	40.2 N	175.2 W	00	27	47	5 NM	16	996.2	11.4	10.6	10	16.5			
FEDERAL NAGARA	LIBERIAN	2	39.5 N	160.8 W	18	26	M 38	2 NM		1002.1	10.0	9.0			26	< 6	8
PEARL VENTURE	LIBERIAN	2	39.7 N	145.5 E	00	33	48	2 NM		1005.0	3.0	3.5	5	8	36	8	16.5
PLUVIUS	GERMAN	2	42.3 N	179.3 W	00	31	37	10 NM	50	999.5	7.5	9.0	7	10	31	8	13
QUEENS WAY BRIDGE	JAPANESE	2	40.7 N	163.7 W	06	24	M 41	5 NM	01	991.5	13.0	10.5	6	13			
TROLL RIVER	BRITISH	2	36.9 N	167.9 W	00	28	38	5 NM	61	1005.8	13.6		5	10	25	>13	11.5
BREWSTER	PANAMANIAN	2	40.1 N	177.3 W	12	30	M 40	2 NM		1012.0	9.0	11.0			30	8	10
ZIM NEW YORK	GERMAN	3	40.0 N	165.6 W	00	27	38	10 NM	25	1010.0	11.8	10.6	8	11.5			
FEDERAL NAGARA	LIBERIAN	3	39.5 N	159.3 W	06	27	M 35	5 NM	01	1009.0	12.1	8.0	5	8	27	6	11.5
PACIFIC WING	PANAMANIAN	3	40.2 N	149.0 W	06	21	M 37	2 NM		1011.0	14.0	11.8	4	6.5	21	6	10
SEALAND TRADE	AMERICAN	3	49.4 N	139.4 W	00	19	35	1 NM	55	1005.5	7.8	6.6			18	< 6	8
PORTLAND	AMERICAN	3	58.9 N	150.8 W	06	02	35	5 NM	50	994.9	9.4	5.6	6	5	09	9	13
OYVI OCEANIC	NORWEGIAN	3	43.1 N	152.8 W	06	27	40	10 NM	82	1001.0	9.0	7.0	6	10	27	X	13
BREWSTER	PANAMANIAN	3	39.9 N	172.3 W	06	29	M 40	5 NM	03	1019.0	13.0	13.0			29	8	8
SANKOLIGHT	LIBERIAN	4	35.0 N	147.5 E	06	10	M 38	.5 NM	65	1006.5	16.0	19.0	6	8	10	7	11.5
PRES JOHNSON	AMERICAN	4	51.8 N	147.0 W	12	26	40	10 NM	02	1001.7	6.7	4.4	6	11.5	21	6	8
PACIFIC VENTURE	PANAMANIAN	4	49.4 N	173.3 W	06	08	M 40	.5 NM		980.6	6.0	6.0			08	7	16.5
SEALAND TRADE	AMERICAN	4	53.1 N	152.5 W	00	28	40	5 NM	58	990.2	4.5	3.4	3	6.5	27	< 6	10
BREWSTER	PANAMANIAN	4	40.6 N	162.2 W	18	20	M 38	1 NM	05	1009.0	12.0	9.5			20	7	10
CRESSIDA	PANAMANIAN	4	50.9 N	175.6 W	12	02	M 36	2 NM	66	984.0	2.0	1.5	7	13			
HONSHU MARU	JAPANESE	4	46.4 N	176.6 E	12	30	M 37	5 NM	27	1000.2	2.5	3.0	8	13	34	11	14.5
GOLDEN RAY	LIBERIAN	5	45.6 N	161.6 W	06	23	M 42	2 NM		997.0	8.0	8.0	6	10			
PACIFIC VENTURE	PANAMANIAN	5	50.2 N	162.1 W	06	15	M 40	200 YD	61	980.5	5.0	3.0			15	8	10
PRES PIERCE	AMERICAN	5	43.4 N	167.4 W	00	25	40	5 NM	15	1003.7	9.4	7.8	5	10	25	>13	23
SEALAND FINANCE	AMERICAN	5	49.5 N	152.2 W	18	19	40	5 NM	02	995.6	5.6	2.7			19	7	8
CAMARA	DANISH	5	39.5 N	166.1 E	18	13	M 40	1 NM	63	1004.0	12.2	10.0	6	6.5			
CRESSIDA	PANAMANIAN	5	51.1 N	172.7 W	00	34	M 36	5 NM	51	984.0	4.5	2.5	8	14.5			
HAWAIIAN MONARCH	AMERICAN	6	37.1 N	124.6 W	12	32	M 40	10 NM	01	1018.0	10.0	10.0	3	6.5	32	6	13
SEALAND FINANCE	AMERICAN	6	49.4 N	148.5 W	00	23	40	10 NM	02	1003.1	7.2	3.3			22	10	6.5
OYVI OCEANIC	NORWEGIAN	6	38.8 N	125.7 W	12	36	37	5 NM	01	1017.0	10.0	13.0	9	13			
HIEI MARU	JAPANESE	7	43.5 N	160.4 W	18	16	M 35	5 NM	51	1006.0	8.5	7.0	5	10	13	8	14.5
HAWAIIAN MONARCH	AMERICAN	7	36.0 N	128.1 W	00	36	M 40	5 NM	02	1020.0	12.2	12.3	3	6.5	36	6	14.5
EXPORT COMMERCE	AMERICAN	7	42.5 N	171.8 E	00	26	40	5 NM	02	999.3	10.6	8.8			26	13	14.5
CAMARA	DANISH	7	42.5 N	179.7 W	12	23	M 44	5 NM	02	1004.1	9.0	7.0	7	10			
SANKOSUN	LIBERIAN	8	47.0 N	160.2 W	00	14	M 48	< 50 YD	53	991.0	8.0	3.0	7	10			
M M DANT	AMERICAN	8	50.3 N	142.0 W	18	11	M 42	2 NM	62	1001.9	9.7	6.1			11	< 6	8
HIEI MARU	JAPANESE	8	43.4 N	157.3 W	00	18	M 35	2 NM	21	1003.0	9.0	7.0	5	10	13	8	13
ANNA MAERSK	DANISH	8	40.7 N	160.2 W	18	27	47	5 NM	03	1003.2	11.2	10.0	10	16.5	27	12	24.5
MELLON	AMERICAN	8	41.2 N	157.0 W	18	28	M 45	1 NM	07	996.6	13.9	10.2	9	16.5			
PACIFIC ARROW	JAPANESE	8	38.0 N	160.0 W	12	29	M 35	5 NM	02	1008.0	13.5						
POLAR ALASKA	LIBERIAN	8	54.2 N	162.9 W	18	05	M 39	.5 NM	28	998.0	3.0	0.0			XX	X	6.5
EXPORT COMMERCE	AMERICAN	8	42.8 N	178.5 W	00	29	35	> 25 NM	01	1011.0	8.4	5.6	4	13	31	6	16.5
CAMARA	DANISH	8	43.1 N	175.6 W	00	28	M 45	5 NM	02	1006.0	11.0	7.0			28	>13	18
MCARTHUR	AMERICAN	9	59.1 N	142.2 W	18	07	M 36	2 NM	62	987.5	5.6	7.1		3	07	10	10
PORTLAND	AMERICAN	9	55.4 N	141.3 W	06	11	40	2 NM	10	994.6	3.9	6.7	7	6.5	09	< 6	13
MEDELENA	FRENCH	9	47.3 N	154.5 W	18	29	M 36	10 NM	02	986.5	8.5	5.6	4	8	27	12	23
MELLON	AMERICAN	9	41.9 N	158.8 W	06	27	M 48	2 NM	16	1000.1	8.5		10	36			
ANNA MAERSK	DANISH	9	40.4 N	155.0 W	06	28	45	5 NM	03	1005.0	11.2	10.0	12	19.5	28	12	24.5
DISCOVERER	AMERICAN	9	58.4 N	151.1 W	12	05	M 38	10 NM	50	995.3	4.6	4.8	3	10			
M M DANT	AMERICAN	9	50.6 N	139.2 W	00	12	M 35	1 NM	58	995.2	12.2	6.1	6	10	14	12	14.5
CAMARA	DANISH	10	43.0 N	156.0 W	18	24	M 40	5 NM	25	999.0	10.2	7.0	9	11.5			
MCARTHUR	AMERICAN	10	59.5 N	144.5 W	00	07	M 35	2 NM	62	984.1	6.2	7.2	XX	5	09	X	14.5
MEDELENA	FRENCH	10	47.1 N	156.4 W	00	29	M 38	5 NM	80	997.0	9.3	5.0	4	10	28	8	23
CAMARA	DANISH	11	43.3 N	153.9 W	00	25	M 38	10 NM	01	1002.1	11.0	7.0	8	14.5			
MONTANA	AMERICAN	11	33.2 N	166.8 E	18	07	35	2 NM	62	1009.0	15.0	17.8	6	14.5			
SANKOLIGHT	LIBERIAN	12	38.2 N	152.6 W	00	30	M 35	10 NM	02	1021.0	14.0	15.0	5	8	27	10	11.5
LETITIA LYKES	AMERICAN	12	35.5 N	169.1 E	03	04	60	2 NM	63	1014.5	14.0	15.0			06	8	18
POLAR ALASKA	LIBERIAN	13	44.8 N	157.4 E	18	22	M 35	200 YD	45	997.0	4.3	2.0	10	10			
POLAR ALASKA	LIBERIAN	14	44.0 N	155.9 E	00	22	M 35	2 NM	21	1000.0	7.0	2.0	10	10			
ASIA HONESTY	LIBERIAN	15	52.0 N	148.0 W	12	32	M 35	10 NM	81	1020.0	4.5	5.0	5	11.5			
CORAL ARCADIA	LIBERIAN	15	54.4 N	164.4 W	18	17	M 35	5 NM	28	1013.8	4.0	3.5	3	5			
ALEUTIAN DEVELOPER	AMERICAN	15	52.7 N	174.1 W	00	20	M 50	5 NM	26	1017.0	2.2	2.3	3	11.5	23	6	10
ALEUTIAN DEVELOPER	AMERICAN	16	53.7 N	167.8 W	12	19	M 40	10 NM	02	997.2	2.2	3.2	2	8			
JAPAN BEAR	AMERICAN	16	36.0 N	143.4 E	12	18	M 43	5 NM	02	1010.5	19.5	18.4	5	10			
CORAL ARCADIA	LIBERIAN	17	53.4 N	170.0 E	12	32	M 36	5 NM	02	996.5	2.0	3.0	3	5	32	8	11.5
LISTA	NORWEGIAN	17	07.3 N	158.8 E	06	10	35(P)	10 NM	25	1005.1	28.0	28.0	5	8			
JAPAN BEAR	AMERICAN	17	39.8 N	153.5 E	12	17	M 45	2 NM	25	1009.0	14.5	12.3			17	9	18
ASIA HONESTY	LIBERIAN	18	51.7 N	169.1 W	00	24	M 35	5 NM	02	1003.0	7.0	4.0	6	10	24	7	14.5
JAPAN BEAR	AMERICAN	18	41.9 N	158.9 E	00	19	M 40	2 NM	10	1006.0	11.7	7.7	5	10	17	8	14.5
LAUREL	LIBERIAN	18	43.9 N	162.5 E	06	17	M 35	.5 NM	45	1005.0	12.0	8.0	8	6.5			
DISCOVERER	AMERICAN	19	59.8 N	145.7 W	18	10	M 38	2 NM	63	1007.1	5.0	5.0	3	8			
THOMAS WASHINGTON	AMERICAN	20	15.5 N	147.7 E	06	07	M 36(P)	1 NM	81	1002.0	26.7	27.6	6	19.5	09	7	24.5
PRES TRUMAN	AMERICAN	21	51.9 N	172.3 E	12	28	35	> 25 NM	03	999.8	4.2	2.2			26	6	8
NEVADA STANDARD	AMERICAN	21	40.4 N	124.5 W	12	33	35	> 25 NM	02	1014.5	11.1	7.8	3	6.5	34	6	10
PRES TRUMAN	AMERICAN	22	51.4 N	167.9 E	00	30	40	10 NM	02	1003.7	2.8	2.2			30	7	13
SEALAND TRADE	AMERICAN	22	37.5 N	148.6 E	06	22	35	2 NM	25	1009.4	17.2	16.7	5	6.5	18	8	13
NEWARK	AMERICAN	24	52.2 N	133.3 W	12	15	35	5 NM	63	994.6	6.7	8.3	4	5	15	8	13
ALEUTIAN DEVELOPER	AMERICAN	25	55.0 N	159.3 W	06	28	M 35	10 NM	02	1009.0	2.3	5.5			28	8	6.5
BALD BUTTE	AMERICAN	25	38.3 N	124.4 W	18	32	35	10 NM	01	1018.3	11.5	10.0			32	7	8
ATLANTIDE	SWEDISH	25	33.2 N	123.3 W	18	34	35	< 50 YD	50	1018.0	13.6	14.0	5	10			
MEDELENA	FRENCH	26	44.0 N	169.0 W	18	11	M 37	1 NM	63	1017.4	7.7	8.5	5	13			
ALEUTIAN DEVELOPER	AMERICAN	26	54.1 N	164.7 W	00	30	M 50	10 NM	03	1023.0	4.3	5.5			30	6	11.5
HILLYER BROWN	AMERICAN	26	38.0 N	123.6 W	00	35	35	10 NM	02	1016.4	12.8	11.1	6	6.5	32	9	10
SEALAND TRADE	AMERICAN	26	50.0 N	136.9 W	12	30	35	10 NM	21	1025.0	3.2	3.9	3	6.5	34	< 6	8
ZOELLA LYKES	AMERICAN	27	28.4 N	130.9 E	00	20	47(P)	.5 NM	07	997.0	22.2	23.8	11	36			
VAN ENTERPRISE	LIBERIAN	27	48.3 N	171.3 W	06	05	M 40	5 NM	21	1015.0	5.0	3.0	8	13			

Vessel	Nationality	Date	Position of Ship Lat. deg.	Position of Ship Long. deg.	Time GMT	Wind Dir. 10°	Wind Speed kt.	Visibility n. mi.	Present Weather code	Pressure mb.	Temperature °C Air	Temperature °C Sea	Sea Waves* Period sec.	Sea Waves* Height ft.	Swell Waves Dir. 10°	Swell Waves Period sec.*	Swell Waves Height ft.
NORTH PACIFIC OCEAN		MAY															
VAN WARRIOR	LIBERIAN	27	26.1 N	149.3 E	00	24	40(P)	5 NM	01	1001.0	27.0	23.0					
NEDELENA	FRENCH	27	44.0 N	168.0 W	00	13	M 38	1 NM	91	1011.0	10.2		6	14.5			
HONGKONG CONTAINER	LIBERIAN	27	45.1 N	177.1 W	00	04	M 37	.25 NM	51	1007.5	6.0	8.0	5	14.5			
DISCOVERER	AMERICAN	27	59.2 N	153.3 W	18	27	M 36	10 NM	02	1006.8	2.6	4.5	2	5			
HONGKONG CONTAINER	LIBERIAN	28	42.3 N	167.0 E	12	11	M 36(P)	.5 NM	80	999.5	10.0	6.0					
ASIA BRAVERY	LIBERIAN	28	53.0 N	137.8 W	00	29	M 36	5 NM	03	1008.5	7.0	7.8	2	8	29	6	14.5
PAN ASIA	PANAMANIAN	29	50.5 N	130.9 W	18	08	M 38	1 NM	65	988.0	5.2	11.0	3	10	08	< 6	13
J H TUTTLE	AMERICAN	29	48.7 N	141.9 W	12	30	40	10 NM	15	1010.6	5.0	6.7	3	13	29	6	19.5
PRES TAFT	AMERICAN	30	46.7 N	167.5 E	05	20	35	.25 NM	45	1001.0	5.5	2.2	12	11.5			
HILLYER BROWN	AMERICAN	30	35.5 N	121.4 W	00	32	35	10 NM	02	1013.8	12.2	12.2	3	5	32	6	13
DISCOVERER	AMERICAN	30	58.8 N	150.6 W	18	29	M 40	10 NM	05	1000.2	4.8	6.0			28	5	6.5
NORTH PACIFIC OCEAN		JUNE															
PRES TRUMAN	AMERICAN	3	37.0 N	147.0 E	06	05	35	5 NM	21	1008.5	17.8	20.6	5	6.5	05	6	8
HONSHU MARU	JAPANESE	4	50.4 N	170.1 E	00	06	M 38	1 NM	25	992.0	8.0	6.0	6	11.5	08	9	14.5
SEALAND COMMERCE	AMERICAN	6	35.5 N	145.7 E	06	16	45	2 NM	12	1007.5	21.2	17.2	7	10			
VAN TRIUMPH	LIBERIAN	6	36.5 N	143.5 E	00	17	M 37	50 YD	65	1003.0	21.0	15.0					
PRES FILLMORE	AMERICAN	6	35.4 N	144.4 E	06	23	35	1 NM		1007.8	20.0	23.9	6	10	23	6	19.5
PACIFIC WING	PANAMANIAN	6	36.2 N	146.0 E	00	15	M 44	.5 NM	80	1011.0	18.0	20.0	4	13			
EXXON BALTIMORE	AMERICAN	8	16.3 N	100.3 W	18	14	35(A)	10 NM	18	1007.8	29.5	32.7			14	8	10
ALASKA STANDARD	AMERICAN	9	57.6 N	154.6 W	00	27	35	10 NM	02	1014.6	7.2	10.0	2	5	27	< 6	8
EXXON BALTIMORE	AMERICAN	9	16.1 N	98.8 W	00	18	35(A)	10 NM	02	1008.0	27.0	31.7	3	6.5	22	8	11.5
KEYSTONER	AMERICAN	9	17.5 N	102.2 W	06	12	40(A)	5 NM	02	1007.3	28.9	29.8	7	10	14	10	10
SEALAND TRADE	AMERICAN	10	52.2 N	174.9 E	12	11	35	2 NM	58	1009.0	3.0	2.2	3	5			
IDAHO STANDARD	AMERICAN	10	58.0 N	150.0 W	00	31	36	10 NM	02	1006.8	7.2	7.8	3	8	30	8	14.5
LAUREL	LIBERIAN	11	34.8 N	140.6 E	06	21	M 39	5 NM	05	1006.0	25.0	23.0	4	5	21	7	10
KRONOLAND	SWEDISH	12	36.2 N	164.2 W	06	20	36	2 NM	64	1007.5	18.2	19.0	8	13			
GALVESTON	AMERICAN	13	53.7 N	138.2 W	18	18	35	2 NM	63	1007.1	7.8	7.8	8	10			
EXPORT BAY	AMERICAN	13	39.8 N	155.7 W	00	21	35	5 NM	25	1008.5	17.2	16.7	6	10			
HONGKONG PHOENIX	SINGAPORE	13	36.4 N	124.1 W	18	35	36	10 NM	02	1017.3	13.5	10.0	5	10	32	8	11.5
ZIM HONGKONG	LIBERIAN	14	30.2 N	147.0 E	18	31	35	5 NM	51	995.5	17.0	19.0	3	6.5	34	6	13
CHALMETTE	LIBERIAN	15	07.1 N	147.1 E	06	07	35	10 NM	60	1008.5	29.0	29.0	3	5			
PRES VAN BUREN	AMERICAN	15	43.2 N	161.6 W	18	20	38	5 NM	03	997.8	14.4	10.6			19	7	8
EXPORT CHALLENGER	AMERICAN	16	38.4 N	158.3 E	12	27	40	5 NM	02	1000.3	18.0	15.7	6	19.5	27	6	24.5
NORBU	NORWEGIAN	16	38.6 N	157.0 E	06	22	40	.5 NM	58	995.0	14.0	13.0		6.5			
PRES VAN BUREN	AMERICAN	16	43.2 N	158.9 W	00	25	35	5 NM	01	1007.1	14.4	10.6		19.5	25	X	24.5
UTE (ATF 76)	AMERICAN	17	38.9 N	123.9 W	06	32	35	10 NM	02	1008.0	12.8	8.9	7	10	32	X	13
FERNLAKE	NORWEGIAN	18	37.5 N	125.6 W	12	02	35	2 NM		1013.2	13.1	14.0			34	8	14.5
WALTER RICE	AMERICAN	22	40.0 N	124.7 W	00	34	40	10 NM	02	1018.0	13.5	11.2	4	11.5	36	8	8
PACIFIC BEAR	AMERICAN	23	42.1 N	152.7 E	12	23	35	10 NM	00	999.0	11.7	12.2	6	6.5	23	11	10
TOYOTA MARU #12	JAPANESE	23	34.6 N	125.3 W	00	34	M 38	5 NM	01	1020.2	13.5	13.5			34	12	14.5
HONGKONG PHOENIX	SINGAPORE	23	45.9 N	155.5 E	12	14	38	50 YD	47	992.0	6.0	6.0	4	8	13	9	10
VAN CONQUEROR	LIBERIAN	24	39.4 N	151.0 E	18	23	M 38	.5 NM	61	1002.0	17.0	18.0					
KANA KEOKI	AMERICAN	25	44.6 N	169.2 W	12	09	M 38	2 NM		1020.4	8.2		6	11.5			
IDAHO STANDARD	AMERICAN	25	41.5 N	126.2 W	18	36	35	10 NM	02	1026.6	13.9	13.3	6	10			
PRES FILLMORE	AMERICAN	26	45.8 N	171.5 E	23	05	34	5 NM	02	1008.0	6.1	9.4	6	13	05	8	29.5
VAN CONQUEROR	LIBERIAN	26	43.2 N	158.6 E	00	08	M 36	.5 NM		1007.0	9.0	10.0					
TRANSONEIDA	AMERICAN	26	33.2 N	174.2 W	18	21	40	2 NM	25	1000.1	21.1	21.7	12	13			
KANA KEOKI	AMERICAN	26	44.6 N	167.2 W	06	08	M 35	1 NM	10	1014.8	8.3		7	14.5			
FERNLAKE	NORWEGIAN	26	29.8 N	165.1 E	18	29	40	2 NM	81	1005.1	24.7	25.0			28	8	14.5
AMER LARK	AMERICAN	26	16.7 N	137.6 E	06	14	40(S)	5 NM	25	1003.4	32.7	27.8	7	18	13	11	18
PRES TAFT	AMERICAN	27	51.9 N	174.4 E	00	05	35	5 NM	01	1021.5	7.2	3.2	5	5	14	9	14.5
PRES FILLMORE	AMERICAN	27	46.8 N	179.6 W	21	06	36	.5 NM	21	999.1	5.6	8.3	6	13	06	8	32.5
TRANSONEIDA	AMERICAN	27	32.5 N	175.3 W	00	21	40	2 NM	25	999.3	21.1	21.1	11	16.5			
TOYOTA MARU #12	JAPANESE	27	36.3 N	166.2 W	18	18	M 36	5 NM	02	1011.0	21.0	19.0			19	9	11.5
ADRIAN MAERSK	DANISH	27	41.0 N	155.0 E	12	09	37	2 NM		1008.0	14.5	14.0					
AMER LIBERTY	AMERICAN	27	40.0 N	167.2 W	12	18	35	1 NM	91	1006.7	15.6	13.9					
SEALAND TRADE	AMERICAN	28	48.7 N	170.4 E	06	02	36	2 NM		1003.0	4.9	3.2	3	6.5	07	7	13
PRES FILLMORE	AMERICAN	28	46.5 N	178.3 W	00	08	40	.5 NM	21	998.8	5.6	8.3	6	19.5	06	8	41
NEDELENA	FRENCH	28	41.8 N	166.0 W	06	16	M 40	5 NM	21	1007.0	16.6	12.4	4	6.5	13	6	10
TOYOTA MARU #12	JAPANESE	28	36.5 N	168.0 W	00	16	M 43	2 NM	20	1008.0	20.0	17.5	4	8	24	8	13
YGUAZU	LIBERIAN	29	19.4 N	121.1 E	06	23	55(R)	1 NM	65	992.5	25.0	29.0	10	23	23	12	32.5
ADRIAN MAERSK	DANISH	29	40.5 N	176.1 E	06	26	35	5 NM	16	999.0	14.2		7	18			

* Direction for sea waves same as wind direction
X Direction or period of waves indeterminate
M Measured wind
(P) Supertyphoon Pamela
(R) Typhoon Ruby
(S) Typhoon Sally
(A) Hurricane Annette

NOTE: The observations are selected from those with winds ≥ 35 kn or waves ≥ 25 ft from May through August (≥ 41 kn or ≥ 33 ft, September through April). In cases where a ship reported more than one observation a day with such values, the one with the highest wind speed was selected.

(Continued from 353.)

about 250 mi south of Guam. The twins moved northwestward for 4 days before recurving to the northeast. Ruby's path took her across Luzon as a typhoon. This overland journey slowed her development. Sally, travelling the friendly Pacific waters, intensified steadily. The AMERICAN LARK encountered 40-kn gales with 18-ft seas and swells on the 26th. Both storms recurved at 20°N --Sally near 132°E on the 28th, and Ruby near 116°E on the 27th. On the 28th, the MEIHO MARU encountered 18-ft swells in 45-kn winds, 120 mi east of Sally's center. Near her center winds had peaked at 110 kn. Another ship 150 mi to the south-southeast was reporting 24-ft swells and 18-ft seas. By the 28th, Ruby had recurved through the Luzon Strait and was reintensifying. The YGUAZU fought 55-kn winds, 23-ft seas, and 33-ft swells on the outskirts of Ruby. On the 30th, the TAKAO SAN MARU reported 40-kn winds 120 mi to the south-southwest of Ruby's center. Ruby reached her 110-kn peak on the 2d as she moved east of the Ryukyu Islands. Ruby was weakening and became extratropical although her winds remained intense as she crossed the 35th parallel near 150°E.

By 0000 on the 4th, Sally was extratropical. The ASIA MOMO, near 41°N, 174°E, reported fighting 55-kn winds and 33-ft swells. The PAN ASIA was within 100 mi of the 970-mb storm center with 40-kn winds and 16-ft waves. The ORIENT PINE was 200 mi to the northwest with 60-kn winds and 16-ft seas. The PRESIDENT MADISON was 180 mi south of the center with 40-kn gales. At 0600 the BREWSTER was ravaged by 70-kn winds. Seas as high as 23 ft were reported. At 1200 four ships reported gale-force winds and waves up to 16 ft. At 0000 on the 5th, the 978-mb storm was near 50°N, 173°E, and the BREWSTER, about 300 mi south of the center, noted 60-kn winds with 20-ft seas and 33-ft swells.

After tracking northward, the storm suddenly turned eastward, on the 5th, leaving a few gale reports along its path.

Casualties--The 10,205-ton Iranian ARYA AKHTAR sustained two periods of heavy weather during which the cargo broke adrift while on loaded passage from San Francisco to Singapore.

Rough Log, North Atlantic Weather

August and September 1976

ROUGH LOG, AUGUST 1976--The major track of storm centers that affected shipping moved along the St. Lawrence River valley, crossed the coast over the Strait of Belle Isle, then curved more northeastward and passed over the Denmark Strait. This closely followed climatology, except the climatic path normally splits southeast of Kap Farvel to pass south of Iceland into the Norwegian Sea. This last part was not present this month nor was a secondary track across Ireland, England, and Denmark. Another major track which normally enters Baffin Bay from southern Hudson Bay was across northern Hudson Bay into Baffin Bay. A storm wandered over the Azores Islands, and another was off the coast of Portugal.

The dominant pressure feature was the Bermuda-Azores High. The monthly mean pattern shows the 1023-mb High centered near 35°N, 38°W, and two 1008-mb Lows--one over Ungava Bay and the other slightly south of Iceland. This month's mean pattern had the 1024-mb Bermuda-Azores High centered near 37°N, 45°W. Another 1024-mb center was over Scotland. The ridges that normally extend over the eastern United States and Europe were more intense than normal producing dry weather. Many areas suffered droughts of varying degrees. The primary Low was 1002 mb and centered over Home Bay on the coast of Baffin Island. A small, closed 1004-mb Low was near Angmagssalik, Greenland. An anomalous 1018-mb Low, near 39°N, 22°W, was imbedded in the Azores side of the Bermuda-Azores High.

The most significant anomaly was plus 13 mb and centered over Scotland. This had a profound effect on the rainfall over northern Europe. Some parts of the United Kingdom had the driest summer on record. The Low in the vicinity of the Azores produced a negative 4-mb anomaly. The pressure over the North Pole produced a minus 13-mb anomaly in that region. The Low over Home Bay resulted in a minus 8-mb center over Baffin Bay.

The upper-air flow at 700 mb was less zonal than usual across the water. The normal shallow trough was over the East Coast of the United States. Another trough between 35° and 40°W was produced by a High off the Bay of Biscay and a pronounced ridge over northern Europe. The significant anomaly was positive over Scotland with the pressure surface 132 m (430 ft) higher than normal.

Extratropical Cyclones--There was only one large extratropical storm this month, and it would have been unusual if there had been more. The fact that most of the circulations that did develop traveled the route between Greenland and Iceland helped hold their size to a minimum owing to the semipermanent HIGH over Greenland and the more pronounced ridge over Europe. The one large storm developed near the Azores Islands.

The first storm with gale-force winds developed almost directly over Kap Farvel at about 0000 on the 3d. The center moved up the East Coast at 990 mb. At 1800 on the 3d, the CHEVIOT, at 53.8°N, 30.7°W, had 35-kn gales with light rain. At 1200 on the 4th, the weather station on the ice cap, near 65°N, reported 40-kn winds, a buoy at 61.8°N, 29.1°W, reported minimal gales, and the MERC had 35-kn winds and 13-ft seas at 60.5°N, 25.2°W. At 0000 on the 5th, a ship near 60.5°N, 27°W, found 35-kn gales and 15-ft seas. By 0000 on the 6th, the wind at Scoresby Sound indicated the LOW was near that position, but there was no other indication of a closed circulation.

This LOW began near 56°N, 52°W, as a frontal wave on the front from the above circulation. At 1200 on the 5th, it was 992 mb just south of Kap Farvel (fig. 47). At 1200 on the 6th, the 984-mb LOW was at 65°N, 38°W. The buoy at 61.8°N, 29.1°W, reported 40-kn winds. The MEERKATZE II at 65.8°N, 26.5°W, off the coast of Iceland had 38-kn southerly winds and 18-ft swells. At 1800 the swells had decreased to 13 ft. The wind at the ice cap weather station was 60 kn from the northwest at 1200. The LOW continued up the Greenland coast to die over the Greenland Sea.

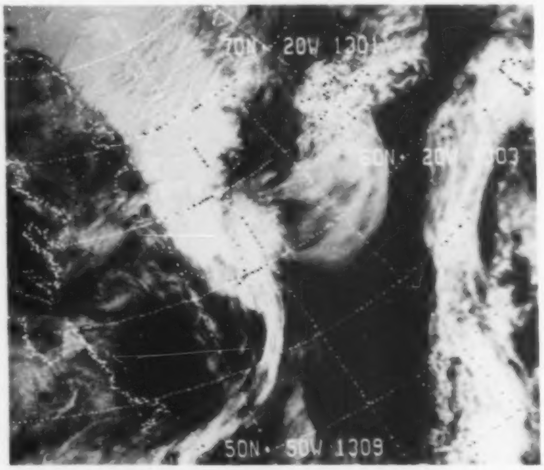

Figure 47.--This polar-orbiting satellite image verifies the surface analysis position.

The northern Great Plains produced the LOW that became this storm. It developed on the 4th and raced eastward as a frontal wave with no deepening until it was over the Labrador Sea on the 7th. By 1200 it was 990 mb southeast of Kap Farvel. As it deepened, it slowed; and by 1200 on the 8th, it was 980 mb near 66°N, 29°W. The buoy near 62°N, 29°W, reported 35-kn gales. The LETCHWORTH, near 57°N, 37°W, had 40-kn gales. At 1800 the buoy reported 45-kn winds. By the 10th, the LOW was absorbed by another following it up the coast of Greenland.

This was an Arctic system that came across northern Canada. It moved across northern Hudson Bay late

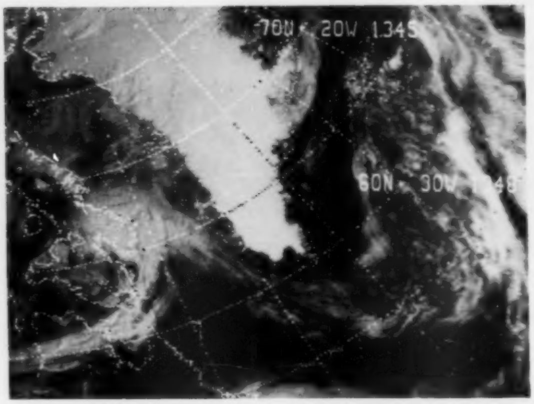

Figure 48.--This is one of the few months when ships can sail through the Davis Strait and be affected by a storm in that area.

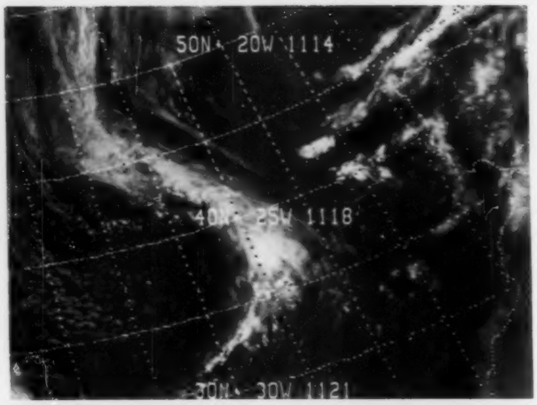

Figure 49.--Only an arc of cloudiness indicates the presence of this storm off the Iberian Peninsula.

on the 9th and early on the 10th. As it neared the Davis Strait, its circulation expanded. At 1200 on the 10th, it was 993 mb near Frobisher Bay (fig. 48). At 1800 the PELICAN (66.1°N, 56.2°W) had 45-kn southeasterly winds and 13-ft waves in the Davis Strait. At 1200 on the 11th, the LOW crashed ashore on Disko Island on the coast of Greenland.

The first indication of this storm was near Windsor, Ontario, on the 15th. It tracked just north of the St. Lawrence River, and the 1000-mb center crossed the Strait of Belle Isle at 1200 on the 17th. It moved across the Labrador Sea with no gales reported. At 0000 on the 19th, the 994-mb center was near 60°N, 25°W. The SEGESHA, at 46.9°N, 36.4°W, was east of the front at 0600 with 42-kn winds. At 1200 the AUENDBORG, at 65°N, 38°W, suffered 44-kn winds at 2°C.

On the 20th, the LOW looped westward back to the coast of Greenland prior to turning eastward and then northeastward again. The LOW continued northeastward and was over Spitsbergen on the 24th.

A cold front moved into the circulation of hurricane Candice on the 24th, and by the 25th the tropical cyclone was extratropical. Frontal waves were forming on the front and moving northward. On the 0000 chart of the 28th, a new frontal wave formed near 43°N, 31°W. The surface LOW moved slightly northward as an upper-air LOW rapidly retrograded westward from near Lisbon. By 0000 on the 29th, they were stacked vertically near 42°N, 32°W.

At 1200 on the 28th (fig. 49), the first gales were observed. Winds of 44 kn from the northwest were reported by the BREMERHAVEN (42.7°N, 32.4°W) and the MASON LYKES (38.5°N, 30.5°W). The highest seas were 13 ft. At 0000 on the 29th, the STRATHANGUS, at 41.2°N, 37.5°W, observed 52-kn winds, 16-ft seas, and 23-ft swells about 250 mi west of the 997-mb center. At 1800 the STRATHANGUS had 37-kn winds with 21-ft swells. Many ships were observing thunderstorms.

The LOW moved southward on the 29th and 30th. On the 31st, it began moving eastward as hurricane Emmy moved eastward. At 1200 Emmy was about 800 mi west of the 1002-mb storm near 37°N, 28°W. The STEINFELS reported 45-kn winds about 300 mi south of the LOW. On September 1, the LOW was filling as Emmy was approaching from the west and absorbing the circulation of the system. At 1800 a SHIP at 39°N, 23°W, reported 60-kn winds from the east. At 0600 on the 2d, the LOW could still be identified, but Emmy was dominating the circulation. The FROSTFJORD was north of the center at 40.7°N, 19.5°W, with 40-kn easterly winds. After 1200 Emmy completed her takeover as hurricane Frances followed to the west-southwest.

Tropical Cyclones--The precursor of Belle moved westward off the African coast on July 28. It was the 20th tropical system of 1976 to be tracked across the Atlantic and was quite well defined.

The wave traveled across the Atlantic at a little more than 20 kn. While the wave itself continued westward across the Caribbean, the major convection separated just east of the Leeward Islands and moved northwestward and slowed down, reaching a position just east of the northern Bahamas on August 5.

Early on the 6th, the surface circulation was sufficiently well defined to upgrade the system to a tropical depression with maximum surface winds of 25 kn and a minimum central pressure of 1012 mb. Intensification was rather steady from the 6th through early on the 9th when the minimum central pressure was determined to be 957 mb and the maximum sustained windspeed was estimated at 105 kn. Belle was upgraded to tropical storm status on the evening of the 6th and to a full hurricane during late afternoon on the 7th (fig. 50). The hurricane classification was based on reports from reconnaissance aircraft as well as the fact that an eye was detected from satellite photographs. The CARNIVALE encountered 40-kn winds some 200 mi west of the center at 0000 on the 8th.

While Belle was a tropical depression and for the first few hours as a tropical storm, her position remained about 250 mi east-northeast of Nassau in the

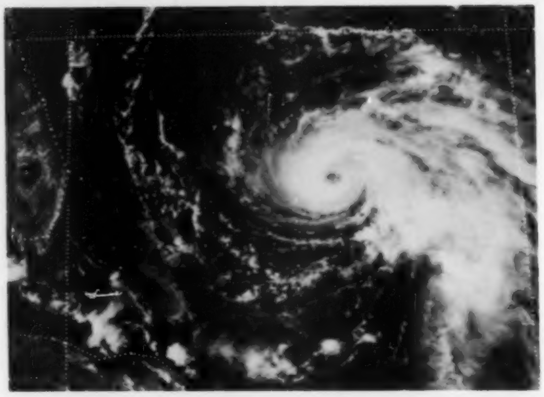

Figure 50.--Belle is approaching hurricane intensity by 1700 on the 7th.

Bahamas. Actually, during this time, she was moving in a small cyclonic loop. Soon after reaching tropical storm intensity, she accelerated toward the northeast, and on the 8th she started moving northward. This direction of motion continued for the next 2 days during which time her forward speed increased to between 20 and 25 kn. At 0000 on the 10th, Belle passed near EB41 which recorded 36-kn winds and 25-ft seas. At the same time OWS Hotel, 150 mi southeast of the center, encountered 45-kn winds in 22-ft seas.

Belle made landfall at 0500 on the 10th on the south coast of Long Island (fig. 51) in the vicinity of Jones Beach. She moved northward across Long Island, then over Long Island Sound, and reached the Connecticut coast near Bridgeport. Her course continued across west-central Massachusetts into southwest New Hampshire and, finally, northeastward into western Maine. During this later period, over New Hampshire and Maine, tropical characteristics were lost.

Estimates of damage caused by strong winds are minimal. Maximum sustained winds reported were less than hurricane force over most of the warning area. Steady 55- to 65-kn northwesterly winds were estimated along the Outer Banks of North Carolina as Belle passed just offshore. As she moved northward, the next highest wind reported was 50 kn with gusts to 60 kn at Ocean City, Md. Along the New Jersey coast, 30- to 40-kn winds were common, but Ship Bottom estimated 55-kn winds gusting to 80 kn, and Manasquan estimated 70-kn gusts. LaGuardia Airport in New York City measured 52-kn northeasterly winds with gusts to 63 kn. Sustained winds of 55 kn were common on the southern shore of Long Island, and an estimated gust to 80 kn was reported from Jones Beach. Finally, as the storm moved across southern New England, there were several instances of gusts above hurricane force, but steady winds were mainly in the 30- to 40-kn range.

Tides associated with the storm surge were generally about 3 ft above normal along much of the coast. However, at some locations from New Jersey southward, tides were somewhat below normal due to an offshore wind component. At Ocean City, Md., esti-

Figure 51.--This line of uprooted trees attests to the strong winds of hurricane Belle as she struck Freeport, N.Y. Wide World Photo.

mates of 4 ft above normal were reported. Battery Park at the southern tip of Manhattan had tides 7.2 ft above MLW or 4.5 ft above normal. No figures have been received from Long Island where it is suspected that some higher tides may have occurred.

Rainfall amounts of 4 to 5 in during the 24-hr period of Belle's passage were common over much of the warning area as well as quite a distance inland, especially in the western and northern mountains of New England.

Because of widespread precipitation throughout the area for a day or two immediately prior to the hurricane, there was considerable flooding of small streams and roads. Crop damage was spotty, and although there were some losses to bottomland crops, the New England Crop and Livestock Reporting Service said, "Damage from Hurricane Belle was much less then anticipated. . ."

There were five storm-related deaths which possibly may be attributed to Belle. In New England, two drowned in southern Vermont when a foot bridge was swept from under them, and in Connecticut a woman was killed in Barkhamstead when her car skidded into a tree. A traffic accident in heavy rain resulted in one death in Norfolk, Va. In New York a falling tree was responsible for one fatality.

It is estimated that nearly one-half million people were evacuated in anticipation of the danger of Belle's storm surge. Available evacuation figures include 250,000 people along the New Jersey shore, 30,000 people in New York City and Suffolk County, N.Y., 5,000 in Connecticut, and 10,000 on the North Carolina coast, as well as unknown thousands elsewhere in New England and along the Eastern Seaboard.

Hurricane Candice had its origin in a baroclinic system. On August 11, a cold Low was clearly evident at 200 mb, but it was not until the 16th that a broad low-pressure area could be drawn on surface charts. The surface Low began to organize, and at 1200 it was classified as a depression, centered near 32°N, 68°W. Satellite pictures showed increasingly better organization, and a ship reported winds gusting to 40 kn. Development continued, and the storm was named at 2200 on the 18th.

As the storm moved northwestward at 15 kn, slight weakening occurred on the afternoon of the 19th and continued until the following afternoon when the storm again began to deepen. Candice became a hurricane during the night of the 20th. The MANCHESTER VIGOUR, 150 mi southwest of the center, encountered 50-kn winds in 20-ft swells late on the 20th. Twenty-four hours later, the BAKAR ran into 45-kn winds amidst 33-ft seas. Maximum intensity was reached on the afternoon of the 22d when the lowest pressure dropped to 964 mb and maximum sustained winds climbed to 80 kn. Early on the 24th, the hurricane was overtaken by a rapidly moving cold front east of Cape Race, Newfoundland. It lost its identity as a tropical system rapidly while accelerating northeastward over the open Atlantic.

Dottie began spectacularly and ended ignominiously. The initial low center formed about 150 mi northwest of Key West during the evening of the 17th in response to a strong upper-level trough which moved rapidly southward into the eastern Gulf of Mexico. By morning on the 18th, the center consolidated between Dry Tortugas and Key West as pressures fell 8 mb in 24 hr in the area. The depression drifted slowly eastward and then northeastward during the next 24 hr with the pressure falling to 1004 mb at Key West by early morning on the 19th.

The system moved rapidly northeastward during the morning of the 19th, and it was named tropical storm Dottie that afternoon as it reached the Atlantic near Palm Beach. Air Force reconnaissance reports indicated 35-kn winds near the middle Keys around mid-morning and 35- to 45-kn gusts in the middle and upper Keys and on Grand Bahama during the day. In addition, 24-hr rainfall amounts of 5 in were common in the greater Miami area with one report of over 8 in in Coral Gables.

Building high pressure north of the storm indicated Dottie would turn more to the west. Also, conditions appeared favorable for further strengthening. Dottie intensified after moving offshore, and an Air Force plane found the storm's minimum central pressure of 996 mb and maximum estimated surface winds of 45 kn around 0600 when the center was about 75 mi east-northeast of Daytona Beach. Strong high-level winds over the storm caused weakening thereafter, and Dottie was barely tropical storm strength at landfall. Gusts of 35 to 40 kn were reported at beach locations near Wilmington, N.C. Tides were 3.5 ft above normal at Atlantic Beach, N.C., and ranged from 1 to 2 ft above normal from Jacksonville Beach to the North Carolina Outer Banks. Carolina Beach, N.C., had a storm rainfall of 7.78 in with 4 to 6 in over coastal North Carolina near Wilmington.

Four deaths resulted when a fishing boat sank on the 19th near Grand Bahama Bank. Damage from the storm was minor, occurring mainly as beach erosion from Georgia to North Carolina.

The disturbance that spawned Emmy moved off the African coast on the 15th. On the 20th, the westward-moving system organized into a tropical depression about 1,000 mi east of the Windward Islands. Development continued, and tropical storm Emmy was christened on the 22d. Emmy turned northwestward. On the 24th, after reaching hurricane strength near 25°N, 65°W, she was pushed eastward by an unseasonal frontal LOW in the mid-Atlantic. She gradually returned to a more northerly course and continued to intensify. A strong blocking ridge over the North Atlantic produced an anomalous westerly flow across the mid-Atlantic near 35°N and caused Emmy to turn eastward again when she reached this latitude on the 28th. The MIR, 60 mi northeast of the center, ran into 55-kn winds that same day.

At this time Frances was developing in the same area where Emmy was christened. As Emmy was peaking on the 29th, Frances reached hurricane strength (fig. 52) on a northwestward track with winds of 90 kn around a 974-mb central pressure. Frances turned northward on the 30th, while Emmy continued eastward along the 35th parallel.

On the 31st, the DIOGENES, 120 mi east of Frances' center, battled 35-kn winds in 20-ft swells, while the GUAVACORE, 60 mi northeast of Emmy, rolled in 25-ft seas and 20-ft swells. Frances continued to close the gap between the two storms as she reached maximum intensity from the 1st through the 4th. Winds near her center, whose pressure had dropped to 963 mb on the 1st, blew at 85 kn. Meanwhile, Emmy slowed and turned northward on the 1st and 2d.

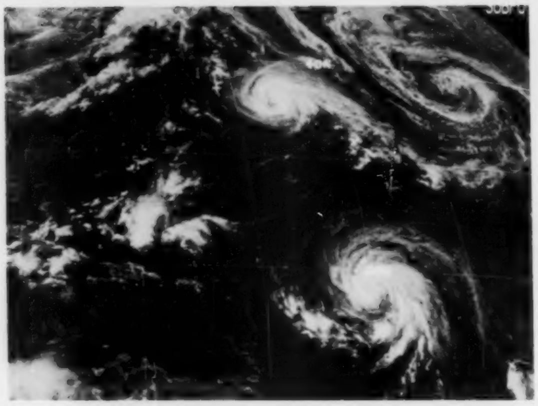

Figure 52.--On the 29th, Emmy to the north at peak intensity, while Frances has just reached hurricane intensity.

She passed over the central Azores on the 3d as Frances was crossing the 30th parallel near 38°W. A Venezuelan Air Force plane, carrying a school choir to Europe, crashed while attempting to land at Lajes Air Force Base in the Azores at the height of the storm. Sixty-eight people were killed.

Frances moved through the Azores on the 5th after absorbing Emmy into her large circulation. However, she was beginning to weaken and turn extratropical. The following day she completed this transformation near 43.5°N, 27°W.

Casualties--The SEMANG PONTOON arrived Trinidad with heavy weather damage sustained on a voyage from San Francisco to Georgetown, Guyana.

ROUGH LOG, SEPTEMBER 1976--Extratropical storm activity along the northern great circle routes was less frequent than normal. This was reflected by large anomalies of plus 13 mb at the surface and plus 118 m at 700 mb. These anomalies were centered over Iceland with lesser values covering much of the eastern North Atlantic. Only a few storms traversed these normally active waters. Extratropical storms were plentiful around the Gulf of St. Lawrence and off the coast of Newfoundland. This resulted in anomaly centers of minus 3 mb at the surface and minus 36 m at 700 mb along the St. Lawrence River.

South of about 45°N, the Bermuda High prevailed at the surface and aloft, except for three tropical and one extratropical intrusions. Hurricanes Emmy and Frances along with an intense LOW were the primary reasons for an area of negative anomalies (maximum minus 3 mb at the surface and minus 40 m at 700 mb) stretching from the Azores to Europe. Tropical cyclone activity was a little below normal with one hurricane, Gloria, developing toward the end of the month.

Extratropical Cyclones--The month opened with the intensification to 965 mb of a Norwegian Sea cyclone. The LOW was spawned northeast of Iceland at the end of August. On September 1, 40- to 45-kn gales raked

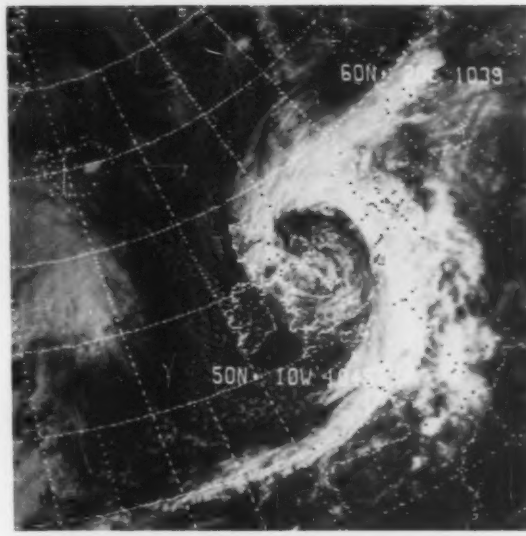

Figure 53.--The LOW is centered off the east coast of Scotland on the morning of the 9th. Dense clouds cover north-central Europe.

the seas between Jan Mayen and the coast of Norway. The storm weakened as it moved across the North Cape the following day. However, a strong flow continued over the Greenland, Norwegian, and North Seas for several more days.

On the 7th, a wave formed just south of Iceland along a stationary front which stretched from Labrador to Scotland. By the 9th, it was an intensifying, 985-mb LOW roaming the North Sea (fig. 53). The DE HOOP sailed into 44-kn northerlies among the Hebrides at 0000. Conditions were no better in the North Sea where ships and rigs were besieged by gales and high seas. Between 54° and 60°N the WHITETHORN, ELIZABETH BOWATER, ROMI, and ODEN DRILL all reported 40- to 45-kn winds. At the northern entrance to the North Sea the ROMI and ODEN DRILL also encountered 20- to 30-ft seas. Conditions worsened on the following day as the LOW swung northward to the coast of Norway and generated a strong westerly to northwesterly flow across the North Sea. Winds of 45 to 50 kn were common. At 0600 the ROMI was still under siege, battling 50-kn northerlies in 25-ft seas near 60°N, 2°E. As the storm attempted to traverse the rugged terrain of Norway and Sweden, another formed near 60°N, 25°W, and moved southeastward. The dying Norwegian LOW had one last gasp and caused the 64-kn winds that whipped the EXPLORA at 1200 on the 11th near 70.8°N, 8.5°E.

Meanwhile, the new LOW had centered itself over the Irish Sea by 0000 on the 11th. Gales were reported all around the 990-mb center. To the southwest, a cold front passage was responsible for 60-kn winds which blocked the English Channel entrance for the TRENTWOOD. Winds of 45 to 50 kn were common, and the GREAT RIVER ran into 25-ft seas off the west coast of Ireland. Along that coast the BELMULLET

reported 45-kn winds. The following day the 990-mb storm moved slowly northeastward and began to weaken.

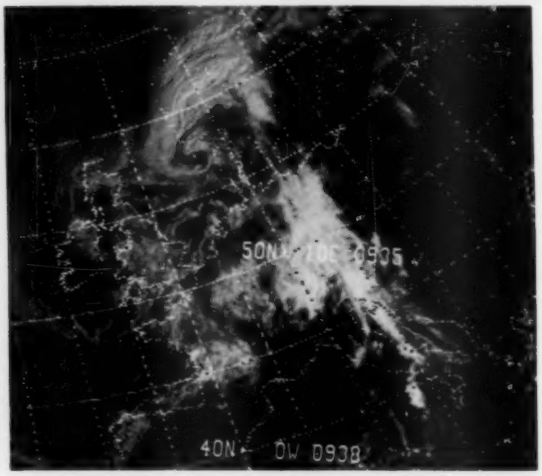

Figure 54.--The heavy rain and strong winds have moved eastward after drenching parts of the rain-starved United Kingdom.

Another storm was brewing in the Denmark Strait on the 12th, however, and soon arrived to take its place among this month's North Sea storms. By 1200 on the 14th, the LOW was centered over southern Norway with a wave along its front over England (fig. 54). The people of the United Kingdom welcomed the storm as they were having the worst drought in 500 yr. In the northeastern sections, 4 in of rain fell in 24 hr with winds to 78 kn--the worst storm in 25 yr. The drought was by no way broken as the heavy rain ran off and did not spread evenly. Water rationing remained in effect, and new restrictions were applied in some areas.

Reports of 40- to 50-kn winds and 10- to 15-ft seas were flocking in from ships northwest and west of the main center. The ROMI, victim of a previous storm, was plagued by 52-kn winds in 25-ft seas near 60°N, 2°E. By 1800 the ROMI moved closer to the coast of Norway, and conditions abated somewhat as winds dropped to 40 kn and seas to 15 ft. The LOW stalled as 40- to 45-kn winds and 10- to 20-ft seas plagued the North Sea, north of 55°N, through the 15th.

That same day a LOW was deepening rapidly south of Greenland. This storm was spawned from a system that had developed over the Great Lakes on the 10th. It had moved northeastward into Quebec and weakened. The remaining frontal system triggered the development of a new LOW just south of Newfoundland on the 13th. By the 15th gales were raging around its 990-mb center. To the south the C7C encountered 42-kn winds in 18-ft seas at 1800. Nearby, the QUEENSGARTH reported 48-kn gales. Early on the 16th, there were several gale reports to the south of the 982-mb center, but by 1200 another system had entered the spotlight.

This new storm had similar origins. It began as a frontal wave along the St. Lawrence River on the 14th. Moving eastward, it intensified off the coast of Newfoundland. By 1200 on the 16th, its center was near 50°N, 42°W, causing gales to the east, west, and south. The C7C, battered by the previous storm, was ripped by 54-kn northwesterlies in 15-ft seas, 100 mi southwest of the storm's center at 0000 on the 17th. The QUEENSGARTH and several other ships encountered 45- to 50-kn winds in 20- to 25-ft seas about 300 mi southeast of the center. The next day a 986-mb center indicated a weakening of the storm.

Early on the 19th, the remnants of the two previous storms combined with a frontal wave in the mid-Atlantic to produce a large, complex, multicentered system. Within a few hours this system got it together into a large LOW with a 981-mb center near 57°N, 30°W (fig. 55). Its circulation ranged from Denmark Strait to the Bay of Biscay. Strong winds were observed in the western semicircle, where they averaged 40 to 45 kn. The THUREDRECHT, 180 mi to the south, sailed through 45-kn winds and 15-ft seas. As the 980-mb LOW traveled toward the east-northeast, a front preceding it swept the English shores with strong winds. Testifying to this was the LEOPARD, which clocked 40-kn winds in the English Channel, and the LE FRINGANT, which battled a 60-kn blow in St. Georges Channel, on the 21st. The next day the LOW turned slowly southeastward and began to fill. Meanwhile, another LOW had formed along the southwest extension of the front. This system was to move east-northeastward, envelop its weakening sister, and become the blockbuster of the month.

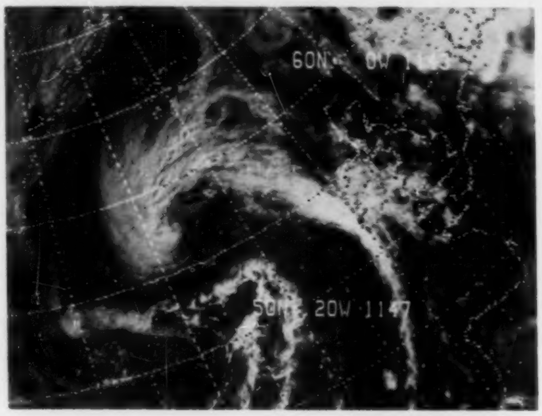

Figure 55.--From the cloud structure at this time, it appears there are still two pressure systems, but the analysis indicated only one.

Monster of the Month--By 0000 on the 23d, the 996-mb center was pinpointed at 47°N, 15°W. The FNXE was battling 64-kn northwesterlies 360 mi to the west. Twelve hours later, the roof fell in as five ships reported winds ranging from 50 to 60 kn. Seas were running 10 to 20 ft. The HUGO OLDENDORFF fought 60- to 65-kn winds in heavy seas for at least 6 hr. The CRANIA and the TEMPLE INN spent the day in 50-kn winds and seas running up to 25 ft. Most of the

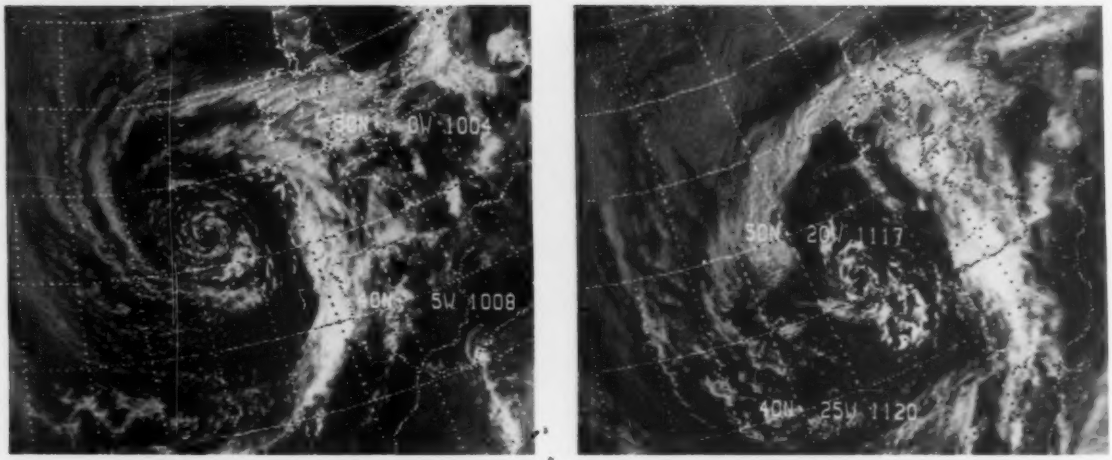

Figure 56.--This vicious September storm caught many ships in its grasp. Note the difference in the cloud pattern after the storm became stationary. Fewer cloud streets are feeding into the center.

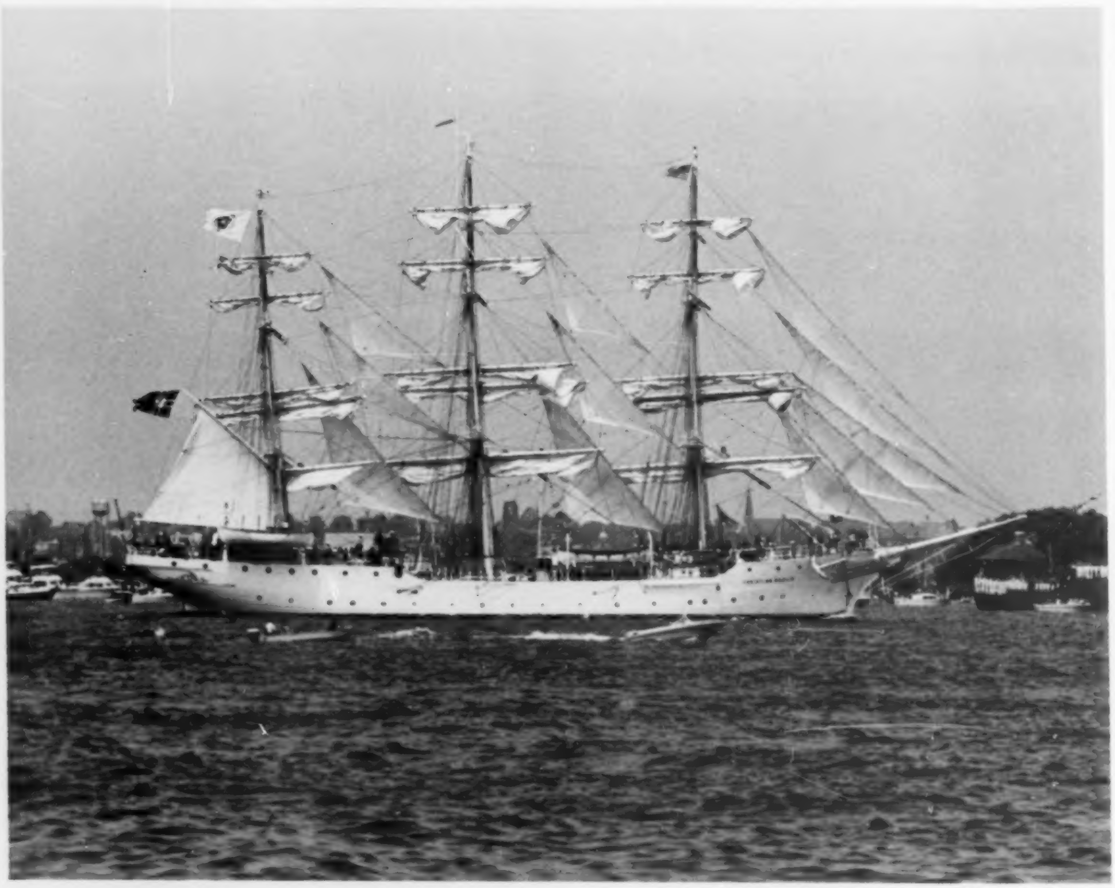

Figure 57.--The Norwegian CHRISTIAN RADICH under better sailing conditions in New York Harbor during Operation Sail. U.S. Navy Photo.

action was south through west of the center and remained that way through the 25th (fig. 56). Into the middle of this mess sailed the Norwegian tall ship CHRISTIAN RADICH (fig. 57) returning from its bicentennial tour of the eastern United States. Its sails were shredded by hurricane-force winds, and the Coast Guard reported that it drifted helplessly for a time. A Norwegian tanker stood by, but the training ship, with a crew of 113, was able to limp into Falmouth harbor under its own limited power. Meanwhile, the storm had become stationary near 47°N, 15°W. On the 25th it began to fill, although you could not prove it by the NOVA GORICA who called in 50-kn winds 200 mi to the southwest. By the 26th, the central pressure had risen to 989 mb, and the LOW began to drift northeastward. It was still on the maps as a weak stationary LOW off Mizen Head as the month came to a close. The 9,733-ton Liberian bulkcarrier APILIOTIS put into Balboa on the 28th to pump water out of the holds which flooded in heavy weather on route from Ponta Delgada, Azores.

The last storm of the month developed from a frontal wave that had moved across New England. On the 28th the budding circulation unveiled over the Gulf of St. Lawrence with a cold front trailing southwestward into the United States. The NOVA GORICA, battle-scarred by the previous storm, encountered 50-kn southerlies some 250 mi southeast of the storm's center. The system intensified rapidly and continued on a northeasterly heading. By the 29th the central pressure had plummetted below 972 mb. Winds of 40 to 50 kn and seas to 20 ft were reported to the south. On the 30th the system was centered off Kap Farvel. Its sphere of influence extended into the Davis and Denmark Straits and south to about 50°N. At month-end the storm's center split in two--one off each coast of Greenland. This division resulted in a rapid weakening of the system.

Tropical Cyclones--Toward the end of a very inactive September Gloria formed in the mid-Atlantic. She developed very rapidly and was christened as a hurricane on the 27th about 550 mi southeast of Bermuda. Gloria meandered northward for a few days. By the 29th winds near her center had climbed to 80 kn with gales extending out about 125 mi. On the 30th and October 1, the NORDIC LOUISIANA and the PEDRO TEIXEIRA battled 40-kn winds within 150 mi of the center, and the latter ship was still buffeted by gales on the 2d. On the 3d the ZVIR reported 44-kn winds 150 mi northeast of the eastward-moving center. Gloria recurved and was heading for the Azores; however, before she reached the Islands on the 5th, she dropped to tropical depression strength.

Casualties--At this time, no reports of casualties other than those mentioned in the text have been received.

Rough Log, North Pacific Weather

August and September 1976

ROUGH LOG, AUGUST 1976--There are three primary climatological extratropical storm tracks this month. North to south, they are: Mys Lopatka to the Bering Strait, northern Honshu to the Pribilof Islands, and from south of the Alaska Peninsula into the Gulf of Alaska. Although the actual tracks this month were not concentrated, two primary tracks were apparent. One extended from Honshu to Nunivak Island and the other from the north-central ocean into the Gulf of Alaska. One odd storm wandered southward off the coast near the Queen Charlotte Islands to southern California.

The mean pressure pattern for the month closely matched the climatological mean. The most prominent feature was the Pacific High at 1025 mb near 38°N, 156°W, versus 1024 mb near 39°N, 150°W, according to climatology. There were two Low centers--1007 mb near 56°N, 176°E, and 1010 mb near 59°N, 160°W--versus only one 1008-mb center near 60°N, 175°E, on the climatological chart.

Since the climatological mean and the monthly mean closely matched, the anomalies were small. The negative 13-mb center near the North Pole did not appear to influence the North Pacific. There were two negative 3-mb centers -- the largest near 56°N, 177°E, and the other at 54°N, 150°W. There was an elongated area of plus 3 mb off Baja California and a positive 4-mb center south of Japan.

Between latitudes 40° and 50°N, the upper-air wind flow was mainly zonal from coast to coast. A Low and trough, rather than trough, were over the Bering Sea with the High centered near 35°N, 160°W, near its climatological position, but the height was slightly higher at 700 mb. A much sharper trough paralleled the North American coast than is indicated by climatology.

There were four tropical cyclones over the eastern ocean--tropical storms Gwen and Joanne and hurricanes Hyacinth and Iva. In the western Pacific, tropical activity started with a bang with supertyphoon

Billie but slowed down after that with three tropical storms--Clara, Dot, and Ellen.

Extratropical Cyclones--The first cyclone to affect shipping during the month formed as a wave on a cold front in the southern part of the Sea of Japan early on the 3d. It moved rapidly eastward and by 1200 was off the east coast of Honshu just northeast of Tokyo. Shipping began to feel its sting as the 998-mb LOW moved northeastward to 40.5°N, 150.5°E, at 0000 on the 4th (fig. 58). In the warm sector near 39.5°N, 153.6°E, the HONG KONG PHOENIX found 40-kn southerly winds and 13-ft seas and swells. Six hours later, bracketing the warm front, the MINETAMA MARU encountered south-southwesterlies of 38 kn near 41.2°N, 155.3°E, and the YUGOH MARU fought 40-kn northerlies at 42.9°N, 153.5°E. The storm continued to move northeastward, and by 1200 on the 4th, the 990-mb LOW was centered near 44°N, 156°E.

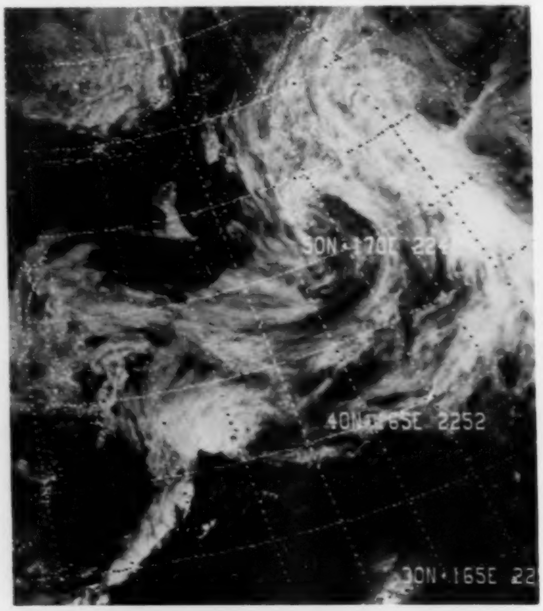

Figure 58.--The warm sector of this storm is sharply defined by the cloud pattern. The SUN BOWL was fighting strong winds many miles to the east generated by the preceding storm.

About 60 mi east of the center, the YUGOH MARU continued to report 40-kn winds, but they had backed to the northwest. A few miles to the north the A8ZG fought northerly winds of 43 kn.

On the 5th the LOW slowed its northeastward movement and began to fill. By 1200 on the 5th, it was near 48°N, 168°E, and beginning to drift toward the northwest. No gale winds were encountered close to the center as the LOW merged with the cyclone that had preceded it on the 6th.

Isolated gales of 48 kn were reported in the preceding LOW by the SUN BOWL on the 4th near 48.4°N, 179°E.

This storm, from its humble beginnings off the east coast of Korea on the 9th, managed to traverse the Pacific, made landfall at Cape Romanzof, Alaska, on the 14th, and died in the Gulf of Alaska on the 15th. Most of its effects on shipping occurred in the western ocean on the 11th and 12th.

The LOW moved east-northeasterly over the Sea of Japan and crossed northern Honshu late on the 9th. By 1200 on the 10th, the 986-mb LOW was near 42°N, 151°E, and ships were beginning to encounter gales. The OJI MARU, just north of the occluded front and 60 mi northeast of the center, was fighting 15-ft seas and 20-ft swells with 34-kn east-northeasterly winds. About 150 mi southwest of the center, the AKAISHI MARU reported 45-kn winds and 15-ft swells. The storm was now moving eastward and deepening. At 0000 on the 11th, the 983-mb LOW (fig. 59) was near 41°N, 158°E, and gales were reported in all quadrants. The JAMSONS fought 56-kn northerlies about 300 mi west of the center, while the H3VX had its problems with 45-kn easterlies. By 0600 two ships in the southern quadrant were reporting 40- to 43-kn winds. The HAKONE MARU with the higher wind was also experiencing the higher swells (26 ft) near 37.4°N, 157.1°E, while the TAIKO MARU was facing 15-ft swells near 38.5°N, 155.2°E.

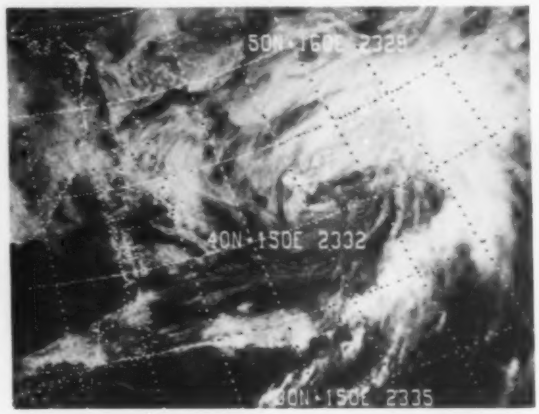

Figure 59.--Note the odd "T-shaped" clear area at the center of the storm.

There were no further reports of gales until early on the 12th when the northeastward-moving storm was near 43°N, 166°E. The A8ZG was stung by 40-kn northerly winds in a rain shower about 100 mi west of the center. Swells were 15 ft. With the LOW increasing the speed of its northeasterly advance, it reached 47°N, 171°E, by 1200 on the 12th. At that time the BREWSTER, 200 mi south of the center, recorded westerly winds of 40 kn. The EHIME MARU was riding 16-ft swells near 42.6°N, 162.9°E.

The weakening storm entered the Bering Sea near the Rat Islands early on the 13th. As the LOW approached Nunivak Island at 0000 on the 14th, a SHIP reported 40-kn westerlies about 550 mi south of the center near 47.8°N, 178.8°W. At 1200 the storm made landfall, then drifted southeastward into the Gulf of Alaska, and dissipated on the 15th.

This LOW developed as an eastward-moving wave near Chi-lin, China, on the 19th. It moved into the Sea of Japan just north of Vladivostok early on the 20th. By the 21st it had crossed Hokkaido to 44°N, 150°E, by 1200. The storm then tracked northeastward and entered the Bering Sea near Attu Island on the 23d. At this point it started to deepen and reached a minimum pressure of 980 mb near 57°N, 180°, at 0000 on the 25th. Gales were encountered south of the center. The WORLD COMMANDER ran into 45-kn southwesterlies near 53.8°N, 177.8°W, while the ALASKAN MAIL was moving along with 44-kn westerlies.

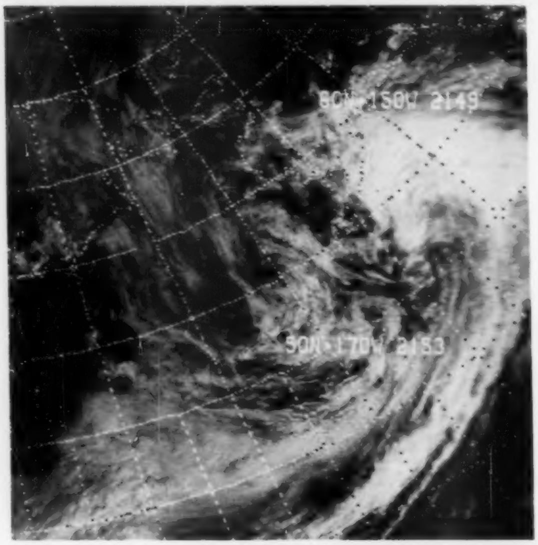

Figure 60.--Both centers are detectable late on the 25th, the original center near 56°N, 171°W, and the secondary one near 52°N, 156°W.

A secondary development occurred about 750 mi southeast of the original LOW on the 24th. This LOW moved northeastward, south of the Aleutians, into the Gulf of Alaska and by the 26th was the dominant circulation. Throughout the 26th gale winds were reported by ships caught in the circulation. At 0000 on that date (fig. 60), the AKAISHI MARU (47.6°N, 154.9°W) struggled with 25-ft swells, 16-ft seas, and 41-kn westerly winds; the BEISHU MARU (50.5°N, 155.2°W) hit winds from the west-southwest of 40 kn; the SUN BOWL (52.5°N, 169.6°W) encountered west-southwesterlies at 46 kn. North of the 978-mb center, near 50°N, 150°W, the IDAHO STANDARD reported 40-kn easterlies with 13-ft seas and swells at 1200. The ship continued to encounter these winds at 1800. Also north of the center at 1800, the USCGC SWEETBRIER battled 33-ft swells and 45-kn easterly winds, while the ALEUTIAN DEVELOPER reported winds from the east-northeast of 45 kn. The storm then filled off Kodiak Island on the 27th and 28th.

Tropical Cyclones, Eastern Pacific--Gwen and Hyacinth formed one day apart within 500 mi of each other (fig. 61). Gwen was spotted on the 5th near 107°W heading westward along the 10th parallel. Hyacinth

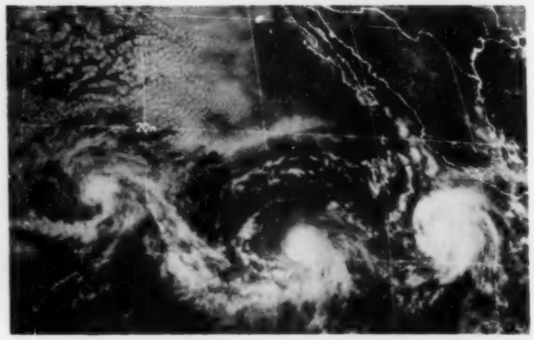

Figure 61.--Gwen (center) and Hyacinth (right) in their developing stages at 1745 on the 7th. The circulation on the left is an unnamed tropical depression near 15°N, 134°W.

turned up the next day farther eastward. Gwen reached tropical storm strength with maximum winds of 55 kn on the 8th. Two days later near 125°W she turned northward. Meanwhile, Hyacinth, heading west-northwestward, found conditions more favorable and reached hurricane intensity on the 9th as she crossed the 110th meridian near 15°N. Her maximum winds climbed to 100 kn on the 11th. Hyacinth began to weaken and turn toward the west-southwest, while Gwen turned northwestward. By the 14th, the two depressions merged near 20°N, 140°W.

Some 250 mi south-southeast of Acapulco, Iva sprung to life on the 24th. Travelling westward, then west-northwestward, she reached tropical storm strength on the 25th. The following day she was a raging hurricane near 15°N, 108°W. She continued to strengthen. On the 28th she passed by the Islas Revillagigedo generating 115-kn winds near her center and gales out 140 mi. This same day Joanne was coming around near 7°N, 90°W. Iva remained a hurricane until the 30th after crossing the 20th parallel near 120°W. By this time Joanne had reached tropical storm strength east of Clipperton Island. Iva was on the wane, and by September 1 she was falling apart near 25°N, 130°W. Joanne was fluctuating between depression and tropical storm strength; she finally lost the battle on the 5th near 14°N, 117°W. However, she lingered as a westward-moving depression until the 8th when she passed the 125th meridian near 13°N.

Tropical Cyclones, Western Pacific--Supertyphoon Billie began life on the 3d some 200 mi north of Saipan. She passed over the island on the 4th as a tropical storm and then headed northwestward. On the 5th the SEALIFT CARIBBEAN, some 200 mi southwest of the center, ran into 35-kn southwesterlies. The following day Billie reached typhoon strength near 17°N, 140°E. Intensifying as she moved west-northwestward, she reached supertyphoon intensity (130 kn) for a few hours on the 7th. On the 8th (fig. 62) the AUSTRALIA MARU, 120 mi southwest of Billie's center, observed 40-kn winds in 15-ft swells. The following day Billie, packing 100-kn winds, crashed into northern Taiwan and rebounded into the Formosa Strait. Before entering mainland China, south of Fuchou, Billie blasted the SEALANDIA with 56-kn winds about 250 mi to the

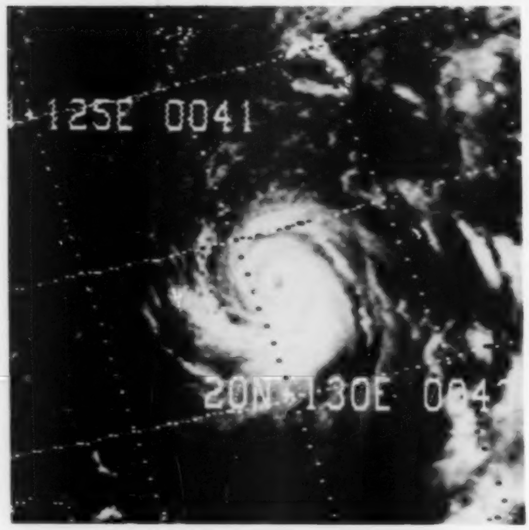

Figure 62.--Billie was close to peak intensity when she posed for this shot at 0042 on the 8th.

south-southeast. In Keelung, the drill ship WODECO VIII broke loose during typhoon Billie and suffered damage to its bow and starboard propellers.

While Billie was plying the western Pacific, Clara flared up about 120 mi south of Hong Kong and then died down. Stunted by the Asian mainland, she reached only tropical storm strength (40 kn) before moving inland on a northwesterly track. Her total life lasted from the 5th through the 7th.

Things were slow until the 18th when Dot arrived near 23°N, 134°E. Within 2 days the Pacific spawned Ellen near 14°N, 132°E. Both moved west-northwestward, but neither reached typhoon strength. Tropical storm Dot's winds peaked at about 50 kn on the 20th as she passed close to Naha, Okinawa, on her way to the East China Sea. Here she recurved, brushed Shanghai on the 21st, and finally moved inland over South Korea the following day.

Tropical storm Ellen remained on a west-northwesterly course as she moved across northern Luzon and into the South China Sea by the 23d. Her winds also peaked at about 50 kn that same day as she turned northwestward. The KIMI MARU encountered 40-kn winds some 200 mi to the south. On the 24th Ellen came ashore just east of Hong Kong.

Casualties--The Cypriot CRETAN STAR has not been heard from since being struck by a large wave during heavy weather off Bombay, India. Disabled from an engineroom fire, the 120,700-ton German tanker NIEDERSACHEN was drifting in force 7 to 8 winds about 300 mi east of Africa in the Indian Ocean on August 25.

ROUGH LOG, SEPTEMBER 1976--The storm tracks off Japan originated off the east coast in accordance with climatology, but they took a more easterly rather than northeasterly path and ended in the Gulf of Alaska rather than the Bering Sea. Several storms developed over the western Bering Sea and tracked toward the west coast of Alaska and the Bering Strait.

The mean monthly pressure pattern differed considerably from the long-term climatology. There was the primary 1020-mb Pacific High centered near 33°N, 170°W, versus the 1021-mb climatic position near 33°N, 145°W. In addition, there were three subcenters--a 1020 mb near 34°N, 140°W, a 1017 mb near 42°N, 164°E, and a 1016 mb near 47°N, 148°E. The two easternmost centers were the most anomalous. Climatologically, a 1010-mb Low is centered not far away near 54°N, 154°E. The Aleutian Low was normally located near 57°N, 160°W, over Bristol Bay. The pressure was 999 mb versus climatology of 1006 mb.

The largest pressure anomaly was minus 8 mb over Bristol Bay. The negative anomaly pattern extended southward to the Equator roughly between 135° and 155°W. The zero line ran from Hawaii to southern Kamchatka. There were two significant positive centers--a plus 3 mb near 30°N, 180°, and a plus 4 mb over Sakhalin Island.

The upper air was similar to climatology in pattern but more intense. The High over the southern Pacific was higher, and the Low over the Bering Sea was lower (700 mb). The normal trough over the Bering Strait was replaced by a closed Low over Bristol Bay.

There were three hurricanes, Kathleen, Liza, and Madeline, over the eastern North Pacific. Hurricane Kate formed over the central Pacific. There were four typhoons (Fran, Hope, Iris, and Joan) plus tropical storm Georgia over the western North Pacific.

Extratropical Cyclones--The first severe storm of the month had its beginning over the Yellow Sea on the 2d as a frontal wave. It moved eastward without any significant development until it reached the Kuroshio Current on the 5th. At that time, it started to deepen and develop a closed circulation. At 0000 on the 7th, the 996-mb LOW was near 40°N, 167°E. The FRIBOLL was about 100 mi north of the center with 40-kn easterly winds and 12-ft seas. At 0600 the ALASKA MARU (42.5°N, 164.5°E) and the BREWSTER (44.3°N, 153.4°E) both fought 40-kn gales.

The storm was moving eastward very slowly. The FRIBOLL was following and had 20-ft swells near 41.5°N, 173°E, at 0000 on the 9th. A large high-pressure area was building over the eastern ocean, and the LOW dissipated by the 10th.

This was one of the storms that formed over the western Bering Sea. An area of low pressure tracked up the Sea of Japan into the Sea of Okhotsk. On the 10th, another LOW developed off the eastern coast of the Kamchatka Peninsula. By 0000 on the 11th, it was 984 mb near 58°N, 175°E. The ASIA ZEBRA near 52°N, 174°E, was sailing into 35-kn gales. A station on the southeastern coast of Kamchatka also measured 35 kn. By the 12th, the circulation around the LOW dominated the ocean north of 45°N. At 1200 the MATEMATIK near 60°N, 179°W, had chilling, 40-kn northwesterly winds.

On the 13th, another LOW was moving eastward along the Aleutian Island chain and sapping the strength and circulation of the older system, which

disappeared late that day.

This was the LOW mentioned above which helped destroy the older LOW. It formed as a frontal wave off Hokkaido on the 11th. Minimal gales were reported early on the 13th, and by 1200 the SOVETSKIE PROFSOYOUS near 51°N, 179°E, reported 40-kn gales and 12-ft seas. At that time, the LOW was 972 mb near 53°N, 177°W. At 0000 on the 14th, the SHOGEN MARU (50.9°N, 172.6°W) was buffeted by 53-kn winds and 13-ft waves. The ATLANTIC MARU, about 70 mi to the north, had 20-ft swells. At 1800 a SHIP at 53.9°N, 158.7°W, was pounded by rain, 50-kn winds, and 20-ft waves (fig. 63).

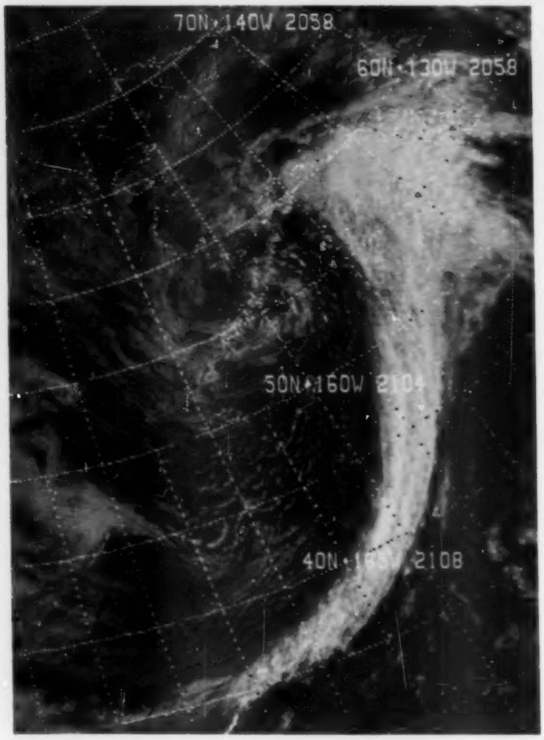

Figure 63.--The center of the LOW (58°N, 160°W) was about 250 mi north of where the ship was pounded by high winds and waves.

On the 15th, the 968-mb LOW was over Bristol Bay. At 0000 the ALEUTIAN DEVELOPER was south of Fox Islands with 50-kn winds and 20-ft waves. The JPVJ at 52.9°N, 141.1°W, radioed 70-kn winds with rain showers. No waves were recorded. At 1200 the PRIOZERSK at 54.2°N, 163.7°W, had 60-kn westerly winds, 13-ft seas, and 20-ft swells. As the LOW moved inland over Alaska, it disappeared.

This storm formed late on the 22d near 37°N, 158°W, south of another LOW as a frontal wave. At 1200 that day, the JAPAN BEAR (42.5°N, 138.6°W) had 40-kn gales and 15-ft seas. At 1200 on the 23d, the LOW was 990 mb near 41°N, 149°W. The ALEUTIAN DEVELOPER at 56.8°N, 153.5°W, was contesting 40-kn gales and 20-ft waves. Late that day, the new circulation absorbed the older one and intensified considerably to 970 mb by 0000 on the 24th at 50°N, 145°W. The ASIA BOTAN at 45.5°N, 164.3°W, fought 44-kn winds. At 1200 on the 24th, the ALEUTIAN DEVELOPER was again involved with 50-kn northeasterly winds and 20-ft swells (fig. 64). On the 25th, the ASIA BOTAN was still contesting 40-kn winds.

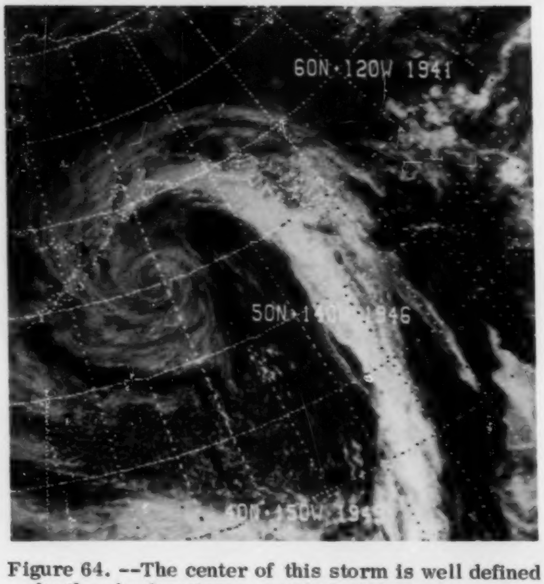

Figure 64. --The center of this storm is well defined by the cloud system near 50°N, 150°W, late on the 24th.

On the 26th, the storm moved inland over the Alaska Peninsula and dissipated, while extratropical Joan moved south of it.

The last significant storm of the month developed south of Honshu on the 27th. On the 28th, the HAGOROMO MARU (35.4°N, 150.8°E) had 45-kn easterly gales north of the center. The PEARL VENTURE at 40.2°N, 152.1°E, suffered 42-kn gales from the east still farther north. The seas were running 13 to 16 ft.

The storm was on an east-northeasterly track. At 1200 on the 29th, the KASHIMA MARU near 45°N, 159°E, had heavy rain and 45-kn winds. At that time, the 972-mb LOW was near 43°N, 156°E. The LOW continued to deepen and was 964 mb by 1200 on the 30th (fig. 65). The KASHIMA MARU was sailing eastward with the storm and now had 50-kn gales on her stern with 13-ft seas.

On October 1, a ship 200 mi south of the center was sailing into 45-kn winds and 25-ft swells. The PEARL VENTURE was now over 600 mi south of the 958-mb center, near 53°N, 176°E, with 50-kn winds and 21-ft swells. Another ship had 45 kn. At 0000 on the 2d, the LOW was 960 mb near 53°N, 180°. A SHIP near 49°N, 176°E, plotted 55-kn winds, 10-ft seas, and 46-ft swells (code 28), but the swells probably were 13 ft (code 08). About 250 mi to the south,

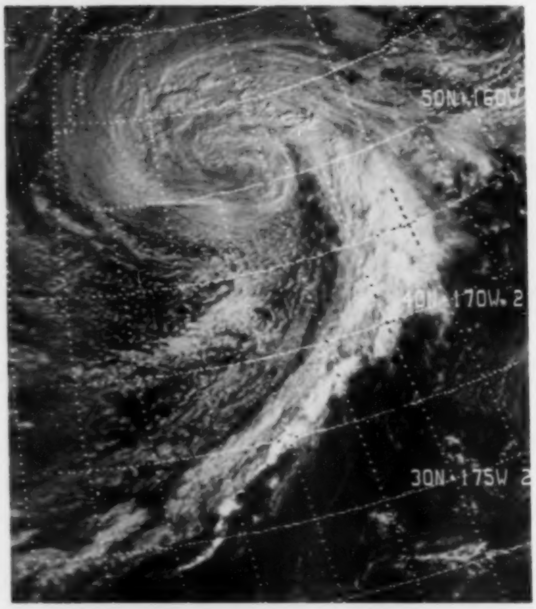

Figure 65.--Cold, high clouds obscure the center of this storm at the surface. Cumulus-type clouds can be seen projecting above the general cloud layer north through east of the center and along the front.

the HASHIMA MARU had 45-kn gales and code 6 and 7 seas and swells.

At 0000 on the 3d, the 973-mb storm was near 52°N, 174°W. The GEORGIANA (48°N, 179°W) had 16-ft seas and 20-ft swells. The TOYOTA MARU (49°N, 175°E) had 40-kn winds and 25-ft swells.

The storm started filling, and the gradient began weakening on the 4th; by the 6th, it had disappeared.

Tropical Cyclones, Eastern Pacific--Kathleen began as a tropical disturbance 300 mi southwest of Acapulco on the 6th. Moving west-northwestward, the disturbance was upgraded to a tropical depression at 0600 on the 7th. Winds increased to 35 kn the following day, and the depression was upgraded to a tropical storm with a center still about 360 mi southwest of Manzanillo. Winds on Socorro at 0600 were from the east at 30 kn; by 1200 they had shifted to the southeast at 45 kn with Kathleen now 130 mi south of the Island. Winds on Socorro increased to 50 kn as Kathleen passed 60 mi to the west at 0300 on the 9th. Moving north-northwestward, Kathleen passed over the western edge of an area of very warm water (in excess of 86°F) off the southern tip of Baja California. Evidently drawing additional energy from the warm water, Kathleen began to intensify and accelerate northward.

The storm was upgraded to hurricane intensity with 70-kn winds at 0000 on the 10th. At 0046 an Air Force reconnaissance aircraft located the center at 25.3°N, 114.8°W, with estimated surface winds of 80 kn and a central pressure of 986 mb. A second flight through the hurricane at 0145 estimated the surface winds at 55 kn and the central pressure at 990 mb. At 0600 on the 10th, hurricane Kathleen was downgraded to a tropical storm again.

Kathleen moved rapidly northward at 30 to 33 kn and crossed the western tip of the Point Eugenia Peninsula on the west coast of Baja California between 0700 and 0800 on the 10th. At 1130 the storm moved onshore 140 mi south of Ensenada and continued northward over the Sierra San Pedro and Juarez mountains. Kathleen crossed into southern California by mid-morning and was centered near Calexico at 1800. By late afternoon the storm had moved over Death Valley and then into western Nevada, about 140 mi southeast of Reno, by 0600 on the 11th. Thereafter, the center was difficult to locate, but gusty winds and rain continued to spread northward into eastern Oregon, Idaho, Montana, Utah, and Wyoming.

The first rain to appear over the southern California desert areas began early on the 9th. By evening, moderate rain was reported at Imperial, Calif. By the morning of the 10th, the rain had spread to western Arizona, southwest Utah, southern Nevada, and as far north as Fresno and Bishop, Calif. Imperial, Calif., reported a surface pressure of 997.3 mb at 1800. Yuma, Ariz., reported the highest wind--66 kn. As the storm continued northward through Death Valley and into western Nevada, it was joined by a low-pressure system moving inland from the southern California coast. This low-pressure system brought additional rain inland over the coastal and interior valleys of central California.

Kathleen left 10.78 in of rain on Mount Wilson, just north of Los Angeles; 14.5 in on San Gorgonio Mountain, northwest of Palm Springs; and 10.13 in on Mount Laguna, east of San Diego. Lake Arrowhead, east of Los Angeles, reported a storm total of 8.71 in. The civic center in downtown Los Angeles reported 1.98 in to bring the season's total to 2.3 in compared to a normal of .06 in for the date.

In the desert, Imperial reported a storm total of 2.22 in; Yucca Valley, 3.36 in; and Palm Desert, which normally receives only 2 in per yr, received 3.57 in. Hardest hit by the storm was the desert town of Ocotillo, about 25 mi west of El Centro near the California-Mexico border. A wall of water moving down Myer Canyon destroyed the Myer Creek Bridge on Interstate Highway 8 causing a gap 700 ft wide and 40 ft deep through the highway (fig. 66). The wall of water, estimated to be one-half mi wide and 4 to 6 ft high, destroyed 70 percent of the homes in Ocotillo and severely damaged another 20 percent. Three deaths were reported, and at least 100 people were evacuated.

Flood waters rushing into the Salton Sea raised its level 6 to 8 in. Several seaside communities were flooded, and at least 75 people were evacuated from Salton City. The New River, flowing from Brawley to the Salton Sea, overflowed its banks when silt carried by the river backed up at its mouth. The river, normally 20 ft wide, swelled to more than one-fourth mi. Flood waters moving through the Carrizo Gorge northeast of Jacumba destroyed three bridges and several miles of track of the San Diego-Arizona Eastern Railway.

Agricultural losses in the Imperial Valley exceeded \$60 million. Sand, silt, and mud carried by flood

Figure 66.--An example of the power of a wall of water 4 to 6 ft high. The energy in an ocean wave several times that high must be tremendous. Wide World Photo.

waters changed the topography and ruined much of the farmland and destroyed most of the elaborate irrigation systems necessary for desert farming. In the San Joaquin Valley of central California most of the raisin crop was destroyed along with late varieties of fruit and nuts; the loss was estimated in excess of $100 million.

In summary, Kathleen, the first tropical cyclone to hit southern California in 37 yr, left five dead in the United States: three in Ocotillo, one in San Bernardino County, and one in Yuma, Ariz. At least 175 people were evacuated from flooded areas, and losses were estimated in excess of $160 million.

In the waning days of the month, Liza was born a few hundred miles southeast of Kathleen's birthplace. By the 26th, near 14°N, 108.5°W, she was christened. Two days later, Liza blew at hurricane force and was making her way northward. Winds climbed as pressure fell. Late on the 29th, winds reached 100 kn, and the following day they peaked at about 115 kn. Ships in the area, including the RICE QUEEN, CRAFTON, and OAKLAND, were fighting seas of 15 to 20 ft. The center of Liza brushed the coast of Baja California on the evening of the 30th. The wind and rain were responsible for widespread damage over the peninsula. La Paz, the capital, was particularly hard hit (fig. 67). The rain-swollen Cajoncito River broke through a shoddily-constructed dike. Most of the estimated 600 to 1,000 deaths were caused by this flood.

As Liza traversed the Gulf of California on her northward journey, she whipped the FAIRSEA, HARRY LUNDEBERG, and the FNSQ with 40-kn winds and seas up to 25 ft. Liza dropped below hurricane force and moved inland near Yavaros on October 1.

The initial impetus for hurricane Madeline was detected near 10°N, 90°W, late on the 28th (fig. 68). However, it was not until October 3, near 11°N, 96°W, that she started to organize. Two days later, the westward-wandering depression reached tropical storm strength. She then turned northwestward. Late on the 6th, Madeline became a hurricane near 13°N, 100°W. A ship 150 mi to the east encountered 45-kn winds in 20-ft swells. On the 7th, the NORSE VIKING, sailing about 120 mi northeast of the center, encountered 40-kn winds at 1200 and 60-kn winds 12 hr later. The ECUADORIAN REEFER fought 56-kn winds and 25-ft seas within 60 mi of the center. By this time, Madeline was moving due north on a collision course with Mexico. Maximum winds were estimated at 100 kn on the 7th and 125 kn on the 8th before she moved ashore about midway between Manzanillo and Acapulco. On the 8th, the LASH ESPANA reported 55-kn winds and 20-ft swells at 0000 and 1200. The FINN LEONHARDT, also rolling in 20-ft swells, reported 41-kn winds. Madeline passed over the mouth of the Balsas River and began to dissipate as she continued farther inland.

In late September, Kate became the first central North Pacific tropical cyclone. She was detected near 12.7°N, 140.7°W, on the 21st. Kate reached tropical storm strength the following day and drifted

Figure 67.--Cars are piled against the foundation of a building in La Paz after the passage of Liza. Much of the city was leveled when an earthen dam burst. Wide World Photo.

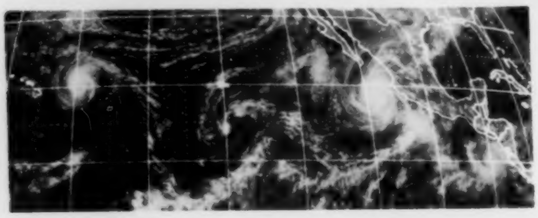

Figure 68.--Hurricane Madeline is just forming west of Costa Rica on the 28th. Liza is south of Baja California, and Kate is bypassing the Hawaiian Islands.

aimlessly. On the 23d, she began moving slowly northwestward toward the Hawaiian Islands. Kate reached hurricane strength on the 24th, but she was still meandering. At 0000 on the 25th, her center was at 14.1°N, 142.8°W. Maximum winds climbed to 90 kn with gales extending out 200 mi on the 26th. Her intensity decreased somewhat as she headed west-northwestward, then northwestward, at about 5 kn. At 0000 on the 28th, Kate's center was spotted near 18.2°N, 146.6°W. At this time, she was beginning to accelerate and was a threat to the Islands (fig. 69). For a while she swung toward the west-northwest on a collision course, but two things happened--Kate weakened to tropical storm strength, and she returned to a northwesterly course away from the Islands. By the 30th at 0600, Kate was near 23.5°N, 152.6°W.

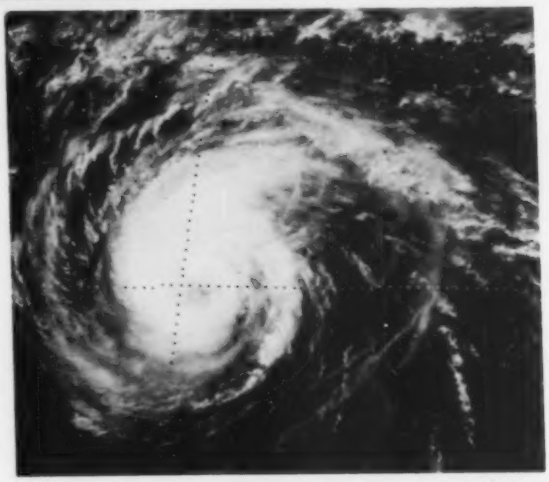

Figure 69.--At 2045 on the 28th, hurricane Kate is about 300 mi east of the island of Hawaii.

Tropical Cyclones, Western Pacific--Supertyphoon Fran was one of the most destructive storms to strike Japan in more than a decade. The preliminary death toll stands at 114 with another 50 people missing. The devastating storm crashed through the Ryukyu

Figure 70.--There are no major traffic jams with this type of commuting in Yokohama. Flooding was widespread as heavy rains blanketed Japan. Wide World Photo.

Islands, near Okinawa, on the 9th. Then she stalled for 2 days just south of Kyushu, pounding southern Japan with strong winds and torrential rains. Fran finally moved across the western part of the island and into the Sea of Japan on the 12th. Most of the damage and death resulted from the prolonged period of heavy rains. Five-day totals of 60 in, more than Tokyo's average annual amount, fell over areas of western and central Japan. Hardest hit was Kochi City, where rivers flooded after 50 in of rain (fig. 70). Throughout Japan, floods swept away 221 bridges and caused 3,577 landslides. Fran was also held accountable for the 138 vessels that were either sunk or damaged.

The typhoon formed along the northern edge of the Caroline Islands on the 3d. Moving northwestward, she passed over Guam as a tropical storm on the 5th. The following day Fran was at typhoon strength. An indication of her intensity was reported by the 30,372-ton Polish freighter UNIWERSYTET TORUNSKI. Steaming about 300 mi northeast of the center, she estimated easterly 80-kn winds at 0600 on the 6th. This may have been a little high; 6 hr later, about 360 mi northeast of Fran's center, the freighter reported 56-kn winds from the east. The ship, steaming southward, had a few days of grace before encountering Georgia. Fran peaked from late on the 7th to early on the 8th when estimated maximum winds climbed to 135 kn. Gales extended out 200 to 300 mi. Fran was threatening the Ryukyus. She weakened considerably before attacking the Islands and Japan. At sea she was still potent. On the 12th, the STRATHARDLE and the WILD FULMAR, both about 200 mi southeast of the center, encountered 45- to 50-kn winds in 25- to 30-ft swells.

Typhoon Fran claimed two casualties. The 52,157-ton Japanese tanker RYOYO MARU suffered a V-shape break amidships in the Bungo Strait and anchored off Saeki. All 62 crew members were rescued after taking to lifeboats. The 23,089-ton British bulk-carrier EASTERN FREEDOM broke all aft moorings at Pohang, damaging propeller and rudder and a Korean naval vessel.

At 0000 on the 14th, extratropical Fran was near 41°N, 135°E. Several ships reported gale-force winds. The EWTI fought 50-kn winds, 26-ft seas, and 27-ft swells at 41.9°N, 142.1°E. At 42.2°N, 141.9°E, the EOHE found 46-kn winds and 20-ft seas. At 0600 the TOURKOUL at 42.3°N, 141.6°E, had 40-kn gales and 23-ft seas. Also, a ship identified as URPS fought 60-kn winds and 31-ft seas near 45.5°N, 138.3°E. The storm was raising havoc with the Soviet fishing fleet. The TCHERNOVTSY caught 48-kn at 1200 (fig. 71).

On the 15th, two ships reported 40-kn gales over the Sea of Japan. Later that day, the LOW turned eastward into the Pacific and died.

While Fran was wreaking havoc in Japan, Georgia attempted to follow in her wake. On the 9th, she formed a few hundred miles east of where Fran began. She reached tropical storm strength the following day, while heading west-northwestward. At 0000 on the

Figure 71.--Even after turning extratropical, Fran was a severe storm as she moved northward over the Sea of Japan.

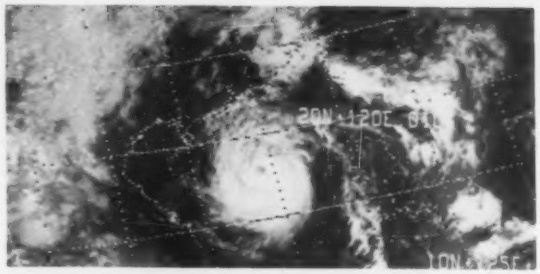

Figure 72.--At her peak, Iris poses in the South China Sea on the 18th.

10th, the UNIWERSYTET TORUNSKI, after a brief respite from Fran, ran into 40-kn northwesterlies 120 mi southwest of Georgia's center. Six hours later, she reported westerly 64-kn winds. However, Georgia's maximum winds were estimated at 50 kn, and she was never upgraded to typhoon strength. On the 13th, she ran into a brick wall around the 15th parallel. Typhoon Fran and a ridge of high pressure kept Georgia confined to the tropics. She meandered eastward looking for an opening but weakened before she found one east of the southern Marianas. By the 14th, she was absorbed into the circulation of tropical storm Hope, which had sprung to life near 18°N, 153°E, earlier in the day.

An unidentified ship just east of Hope's center encountered 45- to 50-kn winds in 15- to 25-ft seas on the 14th. At the same time the COLORADO, west of Palawan in the South China Sea, was battling 45-kn winds in 18-ft seas. This was a clue that Iris was flowering to the north, off Luzon. Hope moved northward and reached typhoon strength by the 15th, while Iris meandered northwestward at tropical storm strength. On the 15th, the CAPE YORK encountered 48-kn winds in 25-ft seas near Hope's center and again found the same conditions a day later more than 300 mi to the southeast of her center. Hope's maximum winds reached 70 kn before she began to weaken and turn extratropical on the 17th as she crossed 40°N, heading north-northeastward. Meanwhile, Iris was getting it together as she reached typhoon strength on the 17th near 18°N, 116°E. Earlier, both the 7JBU and the WAKAURA MARU encountered 40-kn winds in 20- to 25-ft seas. Iris turned west-northwestward toward China. On the 18th (fig. 72), her winds peaked at 75 kn. Iris reached the coast near the Luichow Peninsula the following day. Once inland, she weakened rapidly.

Typhoon Iris claimed the 3,903-ton Panamanian freighter CHIEH LEE, which sank in the South China Sea 200 mi east of Hong Kong. An air-sea search failed to locate 11 crewmen. Thirteen of the crew, floating in lifejackets, were rescued by the Danish freighter EMMA JEBSEN. Four others were known dead. At Hong Kong, the 18,476-ton Liberian tanker OLYMPIC DALE went aground at Junk Bay.

By 0000 on the 18th, a warm front had penetrated to the center of Hope, and she became extratropical near 46°N, 150°E. Four ships radioed reports of 40 kn or greater. The ASIA BOTAN found 46-kn winds south of the center near 36.8°N, 148.9°E. At 1200 the LOW was 974 mb. There were several reports of over 40 kn, with 46 kn again the highest and 13-ft waves the maximum.

At 0000 on the 19th, a SHIP was battered by 16-ft seas and 25-ft swells near 47.5°N, 160°E. The LOW was weakening by the 20th, but the PRESIDENT FILLMORE was buffeted by 50-kn winds and 16-ft waves. On the 21st, the storm absorbed another LOW and found new life. On the 22d, the JAMSONS was hit by 50-kn northerly winds, 34-ft seas, and 25-ft swells near 50.8°N, 172.7°W.

The LOW continued moving eastward and was absorbed by another LOW on the 24th.

While Iris faded over China, Joan came to life about 100 mi east of where Hope had formed. Joan became a typhoon for a day as she headed northward. Her big moment arrived on the 21st when she was crowned a typhoon by the Joint Typhoon Warning Center at 1200. Winds climbed briefly to 70 kn, but her reign ended at 0000 on the 22d when she was downgraded to a common tropical storm. The following day Joan turned north-northeastward and became extratropical.

Joan was still a powerful storm, however. At 1200 on the 24th, a ship encountered 26-ft seas and 24-ft swells within a few miles of the 972-mb center. On the 25th, the storm was racing eastward. On the 25th and 26th, there were no significant wind or wave reports, but there were several on the 27th. The configuration and central pressure of the storm remained about the same. The JAPAN ACE was battered by 40-kn winds and 28-ft swells near 38°N, 150°W, at 0000 on the 27th. At 1200 the SEA-LAND EXCHANGE at 37°N, 146°W, encountered 45-kn winds with the swells running 23 ft.

The LOW had turned southeastward late on the 26th and moved off the coast of California. It finally went ashore near San Diego late on the 29th.

Casualties--The 17,342-ton American PRESIDENT GRANT ran aground outside Keelung Harbor breakwaters on September 1. On the 8th, she was temporarily refloated with the aid of swell from typhoon Fran, but she regrounded. Salvors equipment from Manila was delayed by typhoon Iris. Efforts to refloat were abandoned late in the month, and the ship was declared a total loss.

The Indian bulkcarrier KOLANDIA, Vancouver for Singapore, with a cargo of wheat reported heavy weather damage between Vancouver and Hawaii.

Marine Weather Diary

NORTH ATLANTIC, DECEMBER

WEATHER. December is generally one of the stormiest months of the year over the North Atlantic, particularly north of 35°N. Deep and extensive LOWs traverse the middle and northern shipping lanes, producing strong winds and high seas. Extended periods of rain, sleet, or snow usually attend these storms. A comparison with the normal pressure pattern of the preceding month shows that in December the Azores High remains at about 1021 mb and is centered near 35°N, 33°W. The Icelandic Low deepens 1 mb to 1001 mb; it is located near 62°N, 38°W.

WINDS from the westerly quarter prevail over most of the ocean north of 40°N. Speeds average force 5 to 6 over most western and central waters, and about force 4 over the Bay of Biscay and surrounding waters, the Baltic Sea, and the southern portion of the North Sea. Force 5 to 6 southeasterlies prevail over the northern half of the North Sea, while southerlies of force 4 to 5 are predominant off the central coast of Norway. Winds over the Norwegian Sea are variable at about force 5. Between 40° and 30°N, winds (force 3 to 4) are westerly or southwesterly west of 20°W, northerly or northeasterly between 20°W and the Strait of Gibraltar, and predominantly westerly over the Mediterranean Sea. The "northeast trades," also averaging force 3 to 4, persist between 30° and 10°N, except off the east coast of Florida where winds are variable at force 4. As in November, force 3 southeasterlies prevail over the extreme southern North Atlantic.

GALES. The occurrence of gales is more frequent over northern and middle latitudes than in November. Winds of force 8 or higher occur 10 percent or more of the time from about 34°N over the western North Atlantic to about 40°N over eastern waters. A 10-percent frequency of gales is encountered on the Mediterranean Sea within an area extending nearly 200 mi southeastward from the Gulf of Lions. The incidence of gales is less than 10 percent over the immediate waters east of Newfoundland and over the Davis Strait. Areas of maximum gale frequency--20 percent or higher--are found within an area from the Labrador Sea southeastward to about 44°N, 35°W, then north-northwestward to 56°N, 40°W, then eastward to 55°N, 24°W, then north-northwestward again to the cold waters off southeast Greenland; over much of the Norwegian Sea; and over the Gulf of Lions.

EXTRATROPICAL STORMS. Two primary storm tracks--one from the waters east of the United States Middle Atlantic States and one from the northern Great Lakes -- converge over Newfoundland and then head toward Greenland, where they split into two tracks with one leading into the Davis Strait and the other heading toward Iceland. A large number of LOWs also head toward Iceland from the central ocean east of 40°W and north of 50°N. Another cyclone track enters the Davis Strait from Hudson Bay, while still another runs across the northern coast of Norway from the Norwegian Sea. A primary track stretching from the Gulf of Lions to west-central Italy and then eastsoutheastward to the south coast of Turkey influences the Mediterranean area. The Great Lakes have their highest cyclone frequency of the year during December. The frequency of cyclogenesis over the Gulf of Mexico also reaches it annual maximum during December.

TROPICAL CYCLONES. There is seldom a tropical storm on the North Atlantic in December. During the 45-yr period, 1931-75, only two were recorded; one of these reached hurricane strength.

SEA HEIGHTS of 12 ft or higher occur 10 percent or more of the time north of a line extending from the northwest coast of Spain to approximately 35°N, 70°W, and then east of a line joining that point with Nova Scotia. On the Norwegian Sea, however, sea heights $\geq$ 12 ft usually occur less than 10 percent of the time. Ten-percent frequencies are also found in the Mediterranean between Balearic Islands, Sardinia, Tunisia, and the French Riviera; between Sicily and Crete; and on the northern Aegean Sea. Maximum frequencies of 30 percent or more occur over the Denmark Strait and over much of the western and central ocean north of about 47°N and south of the 60th parallel. An isolated area of 20-percent frequency rests over the Gulf of Lions.

VISIBILITY. The frequency of visibility less than 2 mi climbs to 10 percent over the Labrador Sea, over a pocket-shaped area extending from Kap Farvel south-southwestward to the Grand Banks, over the southern and eastern Davis Strait, and over the southern North Sea. Frequencies of this low visibility are also greater than 10 percent over the area north of a line drawn from the Denmark Strait eastward across northern Iceland, then dipping southward to about 64°N, 7°W, then stretching north-northeastward over the Norwegian Sea, and then eastward to the northern coast of Norway. North of about 72°N, the frequency of visibility less than 2 mi increases to 20 percent and continues to increase as one moves eastward until, after reaching the southern Barents Sea north of the Soviet Union, frequencies reach a maximum of 40 to 50 percent.

NORTH PACIFIC, DECEMBER

WEATHER. December is usually a stormy month over North Pacific waters, particularly in the northern and middle latitudes. The normal pressure distribution is quite similar to that of the preceding month with the Aleutian Low (1001 mb) shifting to near southeastern Kamchatka.

WINDS north of 55°N blow mostly from a northerly direction at force 4 to 6, except over the Gulf of Alaska where force 4 easterlies prevail. Westerly winds of force 3 to 6 are usually felt south of 55°N to about 40°N over the extreme eastern ocean, 35°N over the central-eastern and midocean, and 30°N west of 165°E and east of Japan. Nevertheless, winds over the southwestern Bering Sea show a tendency to be variable, and off the coast of British Columbia the prevailing wind is southerly. Steady "northeast trades" prevail (force 4) between 25°N and the Equator, except

they extend to nearly 35°N off the southwestern California coast. These trade winds merge with the force 4 to 5 winds of the northeast winter monsoon near 140°E. Variable winds (force 3 to 4) lie in a narrow belt between the aforementioned westerlies and northeasterlies. Prevailing winds are largely from the north or northwest and average about force 4 over the Sea of Japan, and the Yellow Sea, and along the southeast coast of Japan. Northerly winds blow steadily out from the Gulf of Tehuantepec, off the south coast of Mexico.

GALES. A larger area of the North Pacific is subject to gales during December than in the preceding month. North of about 39°N over eastern and central waters and 32°N over western waters, 10 percent of the observations contain winds of force 8 or higher. The greatest frequencies, 20 to about 25 percent, occur in three scattered areas from the waters south of the southern tip of the Kamchatka Peninsula south-southeastward to about 34°N, 166°E. Farther north, the frequency of gales decreases to less than 10 percent over the Sea of Okhotsk and the Bering Sea. They are also under 10 percent across a triangularly shaped area southeast of the Aleutians bounded at 53°N, 162°W; 47°N, 163°W; and 49°N, 174°W. Gales are recorded between 5 and 10 percent of the time on the waters surrounding Taiwan, the southern Ryukyus, and the northern portion of Luzon as far east as 144°E, because of the strong development of the northeast monsoon. Gale-force northerly winds occur between 5 and 10 percent of the time out from the Gulf of Tehuantepec.

EXTRATROPICAL CYCLONES. Primary storm tracks extend from the northern portion of the Sea of Japan and the waters east of the Ryukyus to the ocean region lying between Kamchatka and the western Aleutians. From there, LOWs either pass near the Pribilof Islands or continue east-northeastward to the Gulf of Alaska. Another major storm track reaches the Gulf of Alaska from an area south of the Alaska Peninsula near 48°N. The only other primary cyclone track swings toward Vancouver Island from a point 450 mi west of the Oregon coast.

TROPICAL CYCLONES. One tropical storm usually develops over the western North Pacific during December. About two out of every three that do pop up go on to become typhoons. The most likely area of formation is in the neighborhood of the Caroline Islands. Contrary to the events of November, very few of these storms are able to maintain their identity over the South China Sea after traversing the Philippines.

Off the Mexican west coast, tropical cyclones are rare in December.

SEA HEIGHTS of at least 12 ft occur 10 percent or more of the time north of approximately 35°N, east of 150°E, and south of the Alaska mainland, the Aleutian Islands, Kamchatka, and 55°N on the Sea of Okhotsk.

VISIBILITY under 2 mi occurs 10 percent or more of the time north of a line drawn from the lower Tatar Strait to the central Kurils and then northeastward to the western Aleutians where it dips southeastward to about 47°N, 177°W. Upon reaching a point near 47°N, 165°W, the line bends generally northward to Cape Romanzof, Alaska. A much smaller area of 10-percent frequency is centered near 44°N, 143°W. Visibility less than 2 mi encompasses more than 20 percent of all observations poleward of a line cutting through the northern and eastern portions of the Sea of Okhotsk, the northern Kurils, and then northeastward through the Bering Sea to the Bering Strait (passing west of both the Komandorskiye Islands and St. Lawrence Island). A smaller area comprising a 20 percent or greater frequency lies north of the central Aleutians near 54°N, 173°W.

NORTH ATLANTIC, JANUARY

WEATHER. January is generally characterized by rough weather over the middle and northern latitudes of the North Atlantic. LOWs frequently become deep, and associated winds often reach gale and sometimes hurricane force. The Icelandic Low (1000 mb), centered off the extreme southeastern tip of Greenland, is deeper than at any other time of the year. The Azores-Bermuda High with a central pressure of about 1023 mb covers a band from the western Mediterranean Sea west-southwestward to the waters northeast of the Bahamas.

WINDS. North of 40°N, the prevailing winds are westerly over most of the ocean. Over the Norwegian Sea and the North Sea, winds from the southerly quarter prevail. The average wind speeds are predominantly force 4 to 6, except up to 1,200 mi south and east of the southern tip of Greenland and over the Labrador Sea where they reach force 5 to 7. Between 25° and 40°N, the wind direction is from the southwest quarter of the compass over the main body of that portion of the Atlantic, mostly easterly over the Gulf of Mexico, variable over the waters east of Florida, and northerly or northeasterly from west of the Iberian Peninsula to the Canary Islands. Westerlies still dominate over the Mediterranean Sea. Force 3 to 4 winds are the most common except off the coast of the middle Atlantic United States where force 4 to 6 winds prevail. From the Equator to 25°N, the "northeast trades" persist; more than 65 percent of the time wind speeds range from force 3 to 5, except south of 10°N where these winds blow more than 50 percent of the time.

GALES (winds force 8 and higher) occur in 10 percent or more of the observations north of 35°N over the western part of the ocean and north of 40°N over the eastern part. The Mediterranean Sea hosts 10-percent frequencies out to 150 mi from the Gulf of Lions, over the northern Adriatic Sea, and over most of the Aegean Sea. The highest frequency over all North Atlantic waters, 30 percent, is found over a small area centered at about 58°N, 30°W, over a narrow belt off the southern tip of Greenland between 38° and 52°W, and (because of the mistral) over the Gulf of Lions.

EXTRATROPICAL CYCLONES. During the winter months (December, January, and February) LOWs form most frequently in a band 150 to 250 mi wide stretching from the North Carolina-South Carolina border northeastward to about the latitude of Cape Cod. This is part of a large area of cyclogenesis that extends from the Gulf coast of the United States northeastward to the Bay of Fundy. Other principal areas

of cyclogenesis lie over the western half of the central ocean between Newfoundland and the British Isles, over most Icelandic coastal waters, over the inland waters east of the North Sea except the Gulf of Bothnia, and over the Mediterranean from the Gulf of Lions southeastward to the toe of Italy and then northward to the Yugoslavia coast. Cyclogenesis is more concentrated around the waters on both sides of central Italy than anywhere on the North Atlantic during winter with the exception of the band off the United States Atlantic coast. In January, primary storm tracks run from the Carolina capes to Cape Race and from Lake Superior to Cape Bauld. After reaching Newfoundland, cyclones either head northward to the Davis Strait or the Denmark Strait or northeastward to Iceland. Primary storm tracks are also present off the northern Norwegian coast, over the Mediterranean from the Gulf of Genoa to Cyprus, and over the eastern Great Lakes where they join the track toward Newfoundland.

SEA HEIGHTS greater than 12 ft occur 10 percent or more of the time north of 33°N over the western North Atlantic and north of 42°N over eastern waters. Frequencies greater than 10 percent also exist in a small area near Barranquilla, Colombia, and on the Mediterranean between Menorca and Sicily (not including the waters surrounding Corsica), south of Greece and west of Crete, and on the northern Aegean Sea. A large area of frequencies greater than 30 percent stretches from south of Iceland to west of Ireland to east of the Grand Banks and then northward to the waters southwest of Greenland and south of the waters between Greenland and Iceland. Smaller areas of similar frequency are found on the Denmark Strait and west of northern Norway near 67°N, 10°E. The frequency of sea heights greater than or equal to 12 ft decreases to less than 10 percent over a large portion of the Norwegian Sea north of 67°N between 5°E and about 13°W.

VISIBILITY less than 2 mi is noted in more than 10 percent of the observations from Cape Sable eastward to the Grand Banks and northward to Cape Mercy, over the Denmark Strait and the northwestern portion of the Norwegian Sea, and over the southern portion of the North Sea. The frequency increases to more than 20 percent in the Resolution Island area and over the Norwegian Sea north of about 70°N.

NORTH PACIFIC, JANUARY

WEATHER. The most severe weather of the year occurs generally in January over the middle and northern latitudes of the North Pacific. The circulation over the ocean is controlled mainly by the major centers of action--the Aleutian Low, the subtropical High, and the Siberian High. All except the subtropical High are near or at their peak seasonal development. The Aleutian Low, with a central pressure of 1000 mb, is southeast of Kamchatka near 50°N, 165°E, while the axis of the Pacific subtropical ridge exceeds 1021 mb from about 30°N, 135°W, east-northeastward to the State of Wyoming. The wind regime near the Asiatic coast from the Korea Peninsula to the South China Sea is controlled principally by the clockwise flow around the Siberian High (1036 mb), situated over Asia near 49°N, 96°E.

WINDS. Westerly winds prevail over much of the ocean north of 30°N and west of 180°. Northerly winds dominate the East China Sea. Winds are variable over the western Aleutians, southeasterly over the central Aleutians, and northeasterly near the Pribilof Islands. From the Gulf of Alaska southward to near 40°N and east of 180°, winds are mostly westerly to southerly, although other directions are common during the frequent passage of LOWs. Over the extreme northern Gulf of Alaska, the prevailing winds are easterly, and northerly winds are very pronounced over the Bering Sea north of 60°N. The average speed of winds north of 30°N is force 4 to 6, although southeast of Kamchatka the wind blows at force 7, 21 percent of the time. The "northeast trades" extend northward to near 25°N over most of the western and central ocean and to 30°N over eastern waters; south of 20°N, these winds are very steady. The wind speeds in the trades range from force 3 to 5. The "northeast monsoon" is steady over the South China Sea and the Philippine Sea south of 30°N and west of 150°E. Winds are quite variable over the eastern North Pacific between 30° and 40°N, southwesterly over the east-central ocean between 25° and 40°N, and variable over west-central waters between 25° and 30°N and 150°E and 180°. Wind speeds over the above three areas are usually force 4. Northerly winds predominate over the Gulf of Tehuantepec, and in 65 percent of the observations they range between force 2 and 6.

GALES. The frequency of gales near and above 10 percent affects most noncoastal areas south of the Aleutians and north of a line from the waters southeast of Honshu to a point south of the Queen Charlotte Islands and west of Washington State. A maximum incidence of over 20 percent is found over a relatively large region southeast of Kamchatka, over a smaller area east of northern Honshu near 39°N, 154°E, and south of the Gulf of Alaska near 50°N, 145°W. Gale-force northerly winds are encountered more than 10 percent of the time by vessels plying the Gulf of Tehuantepec off southern Mexico. These violent squally winds occur when strong northers from the Gulf of Mexico funnel across the isthmus to the Pacific. In extreme cases, they may be felt more than 200 mi out at sea.

EXTRATROPICAL CYCLONES. Principal areas of cyclogenesis during winter are found from Taiwan on the southwest to the northern Kurils and lower Sakhalin on the northeast and from just north of Marcus Island on the southeast to the western shore of the Sea of Japan on the northwest. The Yellow Sea and Korean coastal waters are not included in this vast region of cyclogenesis. Other smaller areas of cyclogenesis lie over the Pribilof Islands, the Gulf of Alaska, off the North American coast from the Queen Charlotte Islands southward to northern California, and over the east-central ocean about midway between the Aleutian and the Hawaiian Islands. The migratory LOWs move mostly northeastward from the East China Sea and Hokkaido to the western Aleutians and then east-northeastward to the Gulf of Alaska. Other primary tracks approach the Gulf of Alaska and Vancouver Island from the southwest.

TROPICAL STORMS are infrequent in January. On the average, two can be expected every 5 yr over the western North Pacific. Most of these storms develop between 6° and 10°N and west of 150°E and move toward the southern half of the Philippines. Three out of every five January tropical storms achieve typhoon strength.

SEA HEIGHTS greater than 12 ft occur more than 10 percent of the time in an area extending northward from 30° to 35°N to a line drawn from Kodiak Island to the central Aleutians and then to the southeastern waters of the Sea of Okhotsk, and westward from a line 700 mi off the coast of southeastern Alaska and 500 mi off the Oregon coast to 150°E.

VISIBILITY less than 2 mi occurs in 10 percent or more of the observations over an area of the eastern North Pacific between 40° and 50°N and 141° and 162°W, and northwest of a line drawn from Hokkaido to the western Aleutians and then northeastward along the Aleutian chain to the Alaska Peninsula and Cape Avinof. A maximum frequency of over 30 percent encloses a small area over the Okhotsk Basin southwest of Kamchatka.

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